DOCUMENT RESUME

ED 404 520 CE 073 538

AUTHOR	Baker, Andy; And Others
TITLE	Animal Science. Instructor Guide [and] Student Reference. Volume 28, Number 3 [and] Volume 28, Number 4.
INSTITUTION	Missouri Univ., Columbia. Instructional Materials Lab.
SPONS AGENCY	Missouri State Dept. of Elementary and Secondary Education, Jefferson City. Div. of Vocational and Adult Education.
PUB DATE	Feb 96
NOTE	452p.
AVAILABLE FROM	Instructional Materials Laboratory, University of Missouri, 8 London Hall, 2316 Industrial Drive, Columbia, MO 65202; 800/669-2465; http://www.iml.coe.missouri.edu (instructor guide, order no. 10-4005-I: $37.25; student reference, order no. 10-4005-S: $7).
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052) -- Guides - Classroom Use - Instructional Materials (For Learner) (051)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Agricultural Education; *Animal Husbandry; Animals; Competence; Competency Based Education; Course Content; Genetics; High Schools; Job Skills; Learning Activities; Livestock; *Nutrition; *Reproduction (Biology); Teaching Guides; Teaching Methods; Vocational Education
IDENTIFIERS	Missouri

ABSTRACT

This instructor guide and the corresponding student reference contain 4 units that include 30 lessons for a course in animal science for 11th- and 12th-grade agriculture science students. The units cover nutrition, genetics, reproduction, and animal health. The instructor's guide contains the following: objectives, competencies, motivational techniques, teaching procedures, other activities, activity sheets, transparency masters, evaluations, answers to evaluations and activity sheets, 66 references and teaching aids, materials and equipment lists, and a student competency profile. The student reference consists of information sheets and illustrations for the lessons. (KC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

MISSOURI AGRICULTURAL EDUCATION

10-4005-I

ED 404 520

INSTRUCTOR GUIDE

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it

☐ Minor changes have been made to improve reproduction quality

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

Animal SCIENCE

"PERMISSION TO REPRODUCE THIS MATERIAL IN **OTHER THAN PAPER COPY** HAS BEEN GRANTED BY

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

CE 073538

In cooperation with Agricultural Education
Department of Practical Arts and
Vocational-Technical Education
College of Education and
College of Agriculture, Food and Natural Resources
University of Missouri - Columbia

In cooperation with
Agricultural Education Section
Division of Vocational and Adult Education
Department of
Elementary and Secondary Education
Jefferson City, Missouri

BEST COPY AVAILABLE

Available from:

Instructional Materials Laboratory
8 London Hall
Columbia, MO 65211
800/669-2465 or 573/882-2883

Development of this product was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, information or opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

Instructor Guide

ANIMAL SCIENCE

Writer:
Andy Baker
Instructional Materials Laboratory
University of Missouri-Columbia

Consulting Editor:
Richard E. Linhardt
Agricultural Education
University of Missouri-Columbia

Editor and Project Coordinator:
Diane M. Davis
Instructional Materials Laboratory
University of Missouri-Columbia

Volume 28
Number 3

Catalog Number 10-4005-I
February 1996

ACKNOWLEDGMENTS

Recognition is given to advisory committee members for providing their valuable time and suggestions in developing this year-long unit for the 11th and 12th grade agriculture students. The committee consisted of educators Terry Jenkins, Chuck Miller, Tom Strain, and Kyle Whitaker; industry representatives Roger Eakins and Kent Haden; and Jim Bellis of the Department of Elementary and Secondary Education.

Portions of Unit II (Lessons 3, 4, and 6), Unit III (Lessons 4 and 6), and Unit IV (Lesson 6) are courtesy of *Agriscience 332: Animal Science* and *Agriscience 332H: Advanced Animal Science*. Our appreciation is extended to the Instructional Materials Service, Texas A&M University.

Thanks is also given to the following University of Missouri-Columbia staff and faculty for their technical reviews and contributions: Ross Cowart, Kevin Keegan, Bill Lamberson, Mark Newcomb, Richard Randle, Jim Spain, Stacey Wilson. Technical reviews and/or contributions were received by C.A. "Tony" Martin and Shaun Sweiger of MFA, Inc., and Melaney Oberdahlhoff McGaugh.

Appreciation is given to the following staff members of the Instructional Materials Laboratory for their efforts in producing this material: Harley Schlichting, Director; Phyllis Miller and Dan Stapleton, Assistant Directors; Leslie Forbes, Graphic Designer; Janice Trimble, Word Processor; Felicia Lathon, Zuaelie Ahmed, Julie Martin, and Becky Tieman, student assistants; and Paul Kliethermes and Rhonda Woody, Press I.

Diane M. Davis, Editor and Project Coordinator
Instructional Materials Laboratory
University of Missouri-Columbia

Richard E. Linhardt, Associate Professor
Agricultural Education
University of Missouri-Columbia

FOREWORD

Development of this *Animal Science* unit is the result of MVATA Teaching Aids Committee suggestions. The unit was developed to enhance curriculum for 11th and 12th grade agriculture students. Depending on local need, an Animal Science course could replace traditional advanced production course(s).

This instructor guide and the corresponding student reference contain 30 lessons grouped into four units: Nutrition, Genetics, Reproduction, and Animal Health. Transparency masters and activity sheets have been included where appropriate. Check the Table of Contents for a detailed listing of lessons. Additional student reference copies can be purchased separately.

In an effort to provide challenging test questions that reduce guesswork, multiple-choice questions with multiple answers have been included in some of the lesson evaluations. When scoring this type of question, each possible response can be worth one point. Of course, it is the teacher's option to increase the weight of a question, if desired.

During the summer of 1981, the Missouri State Board of Education formally adopted the concept of "Instructional Management Systems" (IMS) as a priority for the 1981-82 school year. The Missouri Commissioner of Education described the IMS concept as a practical way of "organizing for excellence" in education. To meet the demand for greater productivity and accountability, the director of Vocational Education applied the elements of IMS to form the Vocational Instructional Management System (VIMS). The VIMS process provides a framework to use in planning and organizing to assure excellence in Missouri's vocational education system by focusing greater attention on the management of teaching and learning.

This guide incorporates the needed component parts to aid agriculture teachers in the implementation of VIMS. For ease of use, performance objectives and competencies have been included at the beginning of the guide, as well as incorporated within each lesson. A competency profile has been provided in the front of the guide for convenient record keeping.

Jim Bellis, Supervisor
Agricultural Education
Department of Elementary and Secondary Education

Terry Heiman, Director
Agricultural Education
Department of Elementary and Secondary Education

TABLE OF CONTENTS

ACKNOWLEDGMENTS ii

FOREWORD iii

OBJECTIVES vi

COMPETENCIES vii

REFERENCES AND MATERIALS viii

CROSS-REFERENCE TABLE xii

SUGGESTED TEACHING CALENDAR xiv

COMPETENCY PROFILE xv

Unit I - Nutrition

Lesson 1 - Importance of Animal Nutrition to Agriculture I-1
    TM 1.1: Example Feed Tag
Lesson 2 - Livestock Digestive Systems I-11
    TM 2.1: Comparison of Digestive System Parts
    TM 2.2: Digestive System Parts of a Ruminant
    TM 2.3: Digestive System Parts of a Nonruminant
    TM 2.4: Digestive System Parts of an Avian
Lesson 3 - Energy's Role in Livestock Nutrition I-33
Lesson 4 - Protein's Role in Animal Nutrition I-43
    TM 4.1: Protein Utilization in the Ruminant
    TM 4.2: Barrel Stave Illustration of the Effect of Limiting Amino Acid Supplementation on Milk Production
Lesson 5 - Minerals' Role in Animal Nutrition I-57
Lesson 6 - Vitamins' Role in Animal Nutrition I-71
Lesson 7 - Water's Role in Animal Nutrition I-83
Lesson 8 - Environmental Effects on Nutrition I-91
Lesson 9 - Formulating and Balancing Rations I-101
    AS 9.1: Formulating Rations

Unit II - Genetics

Lesson 1 - Importance of Genetics in Agriculture II-1
    AS 1.1: Heritability Traits
    AS 1.2: Beef Herd Selection
Lesson 2 - Basic Building Blocks of Genetics II-15
Lesson 3 - Animal Cell Division II-25
    TM 3.1: Phases of Mitosis
    TM 3.2: Stages of Meiosis
Lesson 4 - Basic Principles of Genetics II-37
    TM 4.1: Punnett Square Examples
Lesson 5 - Tools for Genetic Improvement of Beef II-47
Lesson 6 - Selection Tools for Genetic Improvement of Dairy Cattle II-57
    TM 6.1: Dairy Cow Pedigree

7

Lesson 7 - Tools for Genetic Improvement of Sheep II-67
AS 7.1: Analyzing Performance Data
Lesson 8 - Selection Tools for Genetic Improvement of Swine II-79

Unit III - Reproduction

Lesson 1 - Importance of Reproduction in Livestock III-1
TM 1.1: Comparison of Male Livestock
TM 1.2: Parts of a Cow's Reproductive Tract (Cut-Away View)
Lesson 2 - Reproductive Hormones III-15
Lesson 3 - Reproductive Cycles of Common Livestock III-21
AS 3.1: Reproductive Functions of Livestock
Lesson 4 - Fetal Developmental Stages III-33
Lesson 5 - Effects of the Environment on Reproduction III-43
Lesson 6 - Management and Technology in Reproduction III-51

Unit IV - Animal Health

Lesson 1 - Importance of Animal Health IV-1
Lesson 2 - Immune System of Livestock IV-11
Lesson 3 - Respiratory Diseases Affecting Livestock IV-19
AS 3.1: Respiratory Diseases
Lesson 4 - Diseases of the Gastrointestinal Tract IV-35
Lesson 5 - Reproductive Diseases in Livestock IV-49
Lesson 6 - External and Internal Parasites IV-59
Lesson 7 - Quality Assurance Programs IV-73

OBJECTIVES

Unit I - Nutrition

1. The student will be able to identify the importance of nutrition in livestock.
2. The student will be able to compare and contrast the different digestive systems in livestock.
3. The student will be able to describe the function of energy in livestock nutrition.
4. The student will be able to describe the function of protein in animal nutrition.
5. The student will be able to describe the function of minerals in animal nutrition.
6. The student will be able to describe the function of vitamins in livestock nutrition.
7. The student will be able to understand the function of water in animal nutrition.
8. The student will be able to determine the environmental effects on animal nutrition.
9. The student will be able to formulate a ration for livestock at the teacher's discretion.

Unit II - Genetics

1. The student will be able to describe the importance of an animal's genetic makeup and its effect on agriculture.
2. The student will be able to describe and identify basic building blocks of animal genetics.
3. The student will be able to describe and understand the process of animal cell division.
4. The student will be able to explain and apply the basic principles of genetics.
5. The student will be able to describe the use of selection tools for genetic improvement of the beef herd.
6. The student will be able to use various selection tools and develop a plan to genetically improve dairy cattle.
7. The student will be able to use selection tools for genetic improvement of the sheep flock.
8. The student will be able to describe and choose selection tools to improve a swine operation genetically.

Unit III - Reproduction

1. The student will be able to identify the importance of reproduction in livestock production.
2. The student will be able to describe the hormonal systems in livestock production.
3. The student will be able to understand and describe the reproductive cycles of common production livestock.
4. The student will be able to sequence the fetal development stages of livestock.
5. The student will be able to identify the effects of the environment on the reproductive cycle of breeding stock.
6. The student will be able to describe management and technology utilization to affect the reproductive cycle of livestock.

Unit IV - Animal Health

1. The student will be able to understand the significance of animal health in livestock.
2. The student will be able to describe aspects of the immune system of livestock.
3. The student will be able to understand and describe the diseases of the respiratory system affecting livestock.
4. The student will be able to describe the diseases of the GI tract in livestock.
5. The student will be able to understand and describe the diseases of the reproductive system in livestock.
6. The student will be able to describe the external and internal parasites of livestock and poultry.
7. The student will be able to understand and describe animal health quality assurance programs.

9

COMPETENCIES

Unit I - Nutrition
1. Identify the importance of nutrition to agriculture
2. Compare and contrast the digestive systems of livestock
3. Describe energy's role in nutrition
4. Describe protein's role in nutrition
5. Describe minerals' role in nutrition
6. Describe vitamins' role in nutrition
7. Describe the role of water in nutrition
8. Describe environmental effects on nutrition
9. Formulate a ration for different classes of livestock

Unit II - Genetics
1. Describe the importance of genetics on agriculture
2. Describe the basic building blocks of genetics
3. Describe animal cell division
4. Describe basic principles of genetics
5. Describe selection tools for genetic improvement of beef
6. Describe selection tools for genetic improvement of dairy herds
7. Describe selection tools for genetic improvement of sheep
8. Describe selection tools for genetic improvement of swine

Unit III - Reproduction
1. Identify the importance of reproduction in livestock production
2. Describe the hormonal system in livestock reproduction
3. Describe the reproductive cycle of common production livestock
4. Sequence the fetal developmental stages of livestock
5. Describe the effects of the environment on the reproductive cycle
6. Describe how management and technology are utilized to affect the reproductive cycle

Unit IV - Animal Health
1. Identify the importance of animal health in livestock
2. Describe aspects of the immune system of domestic livestock
3. Describe the diseases of the respiratory system affecting livestock
4. Describe the diseases of the gastrointestinal tract in livestock
5. Describe the diseases of the reproductive system in livestock
6. Describe the major external and internal parasites of livestock
7. Describe animal health quality assurance programs

REFERENCES AND MATERIALS

1. Student Reference

   a) Baker, Andy. *Animal Science (Student Reference).* University of Missouri-Columbia: Instructional Materials Laboratory, 1996.

2. Teacher References

   a) Books, curriculum guides, magazine articles, etc.

      1) *Advanced Dairy Unit.* University of Missouri-Columbia: Instructional Materials Laboratory, 1987.

      2) *Agriscience 332: Animal Science (Student Reference).* Texas A & M University: Instructional Materials Service, 1989.

      3) *Agriscience 332H: Advanced Animal Science (Student Reference).* Texas A & M University: Instructional Materials Service, 1990.

      4) *Animal Breeding Unit (Agricultural Science Core Curriculum).* University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

      5) "Annual Guide to Health and Nutrition." *Pork '93* February 1993.

      6) "Apparent Illegal Digestibility of Crude Protein and Essential Amino Acids in Feedstuffs for Swine - 1992." Chicago, IL: Heartland Lysine, Inc., 1992.

      7) *Black's Veterinary Dictionary.* 16th ed. Geoffrey P. West, ed. London: A & C Black, 1988.

      8) *Careers Unit for Ag Science I Core Curriculum (Instructor Guide).* University of Missouri-Columbia: Instructional Materials Laboratory, 1988.

      9) *Compendium of Veterinary Products.* Port Huron, MI: North American Compendiums, Inc., 1991.

      10) *Livestock and Poultry Breeding (Student Manual).* 2nd ed. The Ohio State University: Agricultural Education Curriculum Materials Service, 1991.

      11) *Livestock Nutrition and Feeding (Student Manual).* 2nd ed. Columbus, OH: Ohio Agricultural Education Curriculum Materials Service, 1991.

      12) *The Merck Veterinary Manual.* 6th ed. Rahway, NJ: Merck & Co., Inc., 1986.

      13) *Milk and Dairy Beef Quality Assurance Program.* Stratford, IA: Agri-Education Inc., 1991.

      14) *Missouri Beef Quality Assurance Program.* Ashland, MO: Missouri Beef Producers, 1990.

      15) *Pork Quality Assurance Program.* Des Moines, IA: National Pork Producers, 1991.

      16) "Seed Stock Tug-of-War." *Successful Farming* February 1994: 35-39.

      17) "Stress Gene: Friend or Foe" *National Hog Farmer* November 15, 1993: 22-31.

18) *Swine Genetics Handbook.* West Lafayette, IN: Cooperative Extension Service, Purdue University, 1988.

19) *Understanding and Using Sire Summaries (GO2032).* University of Missouri-Columbia: Extension Division, 1986.

20) "Zoonosis Updates for the Journal of the American Veterinary Medical Association." Schaumburg, IL: American Veterinary Medical Association, 1990.

21) Blakely, J.; D. Bade. *The Science of Animal Husbandry.* 6th ed. Englewood Cliffs, NJ: Prentice-Hall, 1994.

22) Blakely, James. *The Brass Tacks of Animal Health.* St. Louis: Doane Agricultural Service, Inc., 1978.

23) Campbell, J.; J. Lasley. *The Science of Animals that Serve Mankind.* New York: McGraw-Hill Book Company, 1969.

24) Cowart, Ross. "Diseases of Swine." Class handout prepared for VP230: Animal Sanitation and Disease Prevention. University of Missouri-Columbia: College of Veterinary Medicine, n.d.

25) Cullison, Arthur Edison. *Feeds and Feeding.* 4th ed. Reston, VA: Reston Publishing Co., 1987.

26) Ensminger, M. E. *Animal Science Digest.* Danville, IL: Interstate Publishers, Inc., 1991.

27) Ensminger, M. E. *Poultry Science.* 3rd ed. Danville, IA: Interstate Publishers, Inc., 1992.

28) Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

29) Ensminger, M. E., and C. G. Olentine, Jr. *Feeds and Nutrition.* 2nd ed. Clovis, CA: The Ensminger Publishing Company, 1990.

30) Gillespie, James R. *Animal Nutrition and Feeding.* Albany, NY: Delmar Publishers, Incorporated, 1987.

31) Gillespie, James R. *Modern Livestock and Poultry Production.* 4th ed. Albany, NY: Delmar Publishers, Inc., 1992.

32) Hafez, E. S. E. *Reproduction in Farm Animals.* 6th ed. Philadelphia, PA: Lea & Febiger Publishing, 1993.

33) Herman, Harry A. *The Artificial Insemination and Embryo Transfer of Dairy and Beef Cattle: A Handbook and Laboratory Manual.* 8th ed. Danville, IL: Interstate Publishers, Inc., 1994.

34) Hungerford, T. *Diseases of Livestock.* 9th ed. Sydney, Australia: McGraw-Hill Publishing, 1990.

35) Johnson, Philip J. "Introduction to Colic." Class handout prepared for VMS 610: Equine Medicine and Surgery. University of Missouri-Columbia: College of Veterinary Medicine, n.d.

36) Keegan, Kevin G. "Colic Surgery." Class handout prepared for VMS 610: Equine Medicine and Surgery. University of Missouri-Columbia: College of Veterinary Medicine, n.d.

37) Largen, Velda L. *Guide to Good Food.* South Holland, IL: Goodheart-Willcox Company, Inc., 1988.

38) Lasley, John. *Genetics of Livestock Improvement.* 4th ed. Indianapolis: Prentice-Hall, 1986.

39) McLaren, J.; L. Rotundo. *Heath Biology.* Lexington, MA: D. C. Heath and Company, 1985.

40) Oram, Raymond F. *Biology Living Systems.* Columbus, OH: Merrill Publishing Company, 1989.

41) Pasquini, Chris, and Susan Pasquini. *Student Guide to Bovine Clinics.* Pilot Point, TX: Suds Publishing, 1993.

42) Rebhun, William C. *Diseases of Dairy Cattle.* Baltimore: Williams & Wilkins, 1995.

43) Smith, Robert. *Animal Science 11 (Student Reference).* University of Missouri-Columbia: Animal Science Department, 1989.

44) Stufflebeam, C. *Principles of Animal Agriculture.* Englewood Cliffs, NJ: Prentice-Hall, 1983.

45) Taylor, R., and R. Bogart. *Scientific Farm Animal Production.* 3rd ed. New York: Macmillan Publishing Co., 1988.

46) Taylor, Robert E. *Beef Production and Management Decisions.* 2nd ed. New York: MacMillan Publishing Co., 1994.

47) Thomas, D. "National Sheep Improvement Program: The Means to an End." *National Wool Grower* June 1989: 30-33.

48) Williams, James E. *Animal Science 202: Principles of Animal Nutrition Handbook.* University of Missouri-Columbia: Animal Science Department, 1990.

49) Winkler, J. *Farm Animal Health and Disease Control.* 2nd ed. Philadelphia: Lea & Febiger Publishing, 1982.

b) Audiovisuals (available for loan to Missouri educators from the Missouri Vocational Resource Center, 8 London Hall, Columbia, MO 65211. 800/392-7217 or FAX 573/882=9935.)

1) *Horse Feeding and Nutrition* (AG SL 23)

2) *Cutting Costs . . . Pocketing Profits* (12 minutes)

3) *Profit by Using EPDs* (14 minutes, AG video 147)

4) *Cattle Breed Identification: Dairy* (21 minutes, AG video 220)

5) *Beef Reproduction II* (43 minutes, AG video 7)

6) *Embryo Transfer of Beef and Dairy Cattle* (13 minutes, AG video 177)

7) *Artificial Insemination of Beef and Dairy Cattle* (10 minutes, AG video 178)

8) *Cattlemen Care About Animal Welfare* (10 minutes, AG video 188)

9) *Cattlemen Care About Beef Safety* (12 minutes, AG video 190)

c) University of Missouri-Columbia Extension Division agricultural publications

1) GO2032: Understanding and Using Sire Summaries
2) GO2851: Health Hints for Your Horse

d) Computer Resources

1) The NSIP is a computer-based program that provides output on the most accurate estimates of genetic merit for economically important traits. This output is based on individual sheep available in the U.S.; contact the local extension office for information on the program.

2) Stallings, Charlie, et. al. *DAIR4* (IBM dairy and beef program). Blacksburg, VA: Virginia Tech. (Can be downloaded from Agriculture Electronic BBS, 573/882-8289, system operator 573/882-4827)

3) *Taurus* (IBM cattle ration program). University of California-Davis, 1990.

4) *Apollo* (iBM swine ration program). University of California-Davis, 1990.

5) Extension Publications Library on Request (XPLOR) is an infobase on CD-ROM. It represents nearly 1,400 existing University of Missouri Extension publications. In the nearly 900 available full-text publications, there are more than 450 color graphics and photographs. Users will hear state horticulturalist Ray Rothenberger elaborate on more than 125 color photographs included in 25 publications. More than 400 additional publications are abstracted, and more than 100 additional titles are listed.

Also included on this disc are the University Extension Directory for the University of Missouri System and the MU Center for Independent Study Course Catalog.

Minimum computer requirements are: IBM-compatible machine with 80386 or better processor, ISO 9660 compatible CD-ROM drive, Microsoft Windows 3.1, 4 megabytes of RAM, and at least 4 MB free space on the hard drive.

For the special academic price, call 800/292-0969 or write to Extension Publications, 2800 Maguire, University of Missouri, Columbia, MO 65211. E-mail can be sent to xplor@ext.missouri.edu.

6) The Agricultural Electronic Bulletin Board Service contains a wealth of information. It is available via modem call at 573/882-8289, 9600 baud, protocol N-8-1 or E-7-1.

CROSS-REFERENCE TABLE

Animal Science Competencies	Missouri Core Competencies and Key Skills for Science
Unit I - Nutrition	
1. Identify the importance of nutrition to agriculture	
2. Compare and contrast the digestive systems of livestock	
3. Describe energy's role in nutrition	
4. Describe protein's role in nutrition	
5. Describe minerals' role in nutrition	
6. Describe vitamins' role in nutrition	
7. Describe the role of water in nutrition	
8. Describe environmental effects on nutrition	
9. Formulate a ration for different classes of livestock	
Unit II - Genetics	
1. Describe the importance of genetics on agriculture	10C-1: Predict the phenotypic and genotypic ratios of the offspring of a dihybrid cross using a Punnett square 10C-4: Associate the roles of genetic variation and natural selection with change in organisms over time
2. Describe the basic building blocks of genetics	10B-1: Describe the functions of the organelles of a cell (cell wall, cell membrane, nucleus, ribosome, mitochondrion, chloroplastid, vacuole) 10B-3: Describe the structure and function of DNA 10D-8: Compare and contrast photosynthesis and cellular respiration
3. Describe animal cell division	10A-2: Distinguish between mitosis and meiosis 10B-1: Describe the functions of the organelles of a cell (cell wall, cell membrane, nucleus, ribosome, mitochondrion, chloroplastid, vacuole)
4. Describe basic principles of genetics	10C-1: Predict the phenotypic and genotypic ratios of the offspring of a dihybrid cross using a Punnett square 10C-4: Associate the roles of genetic variation and natural selection with change in organisms over time 10D-9: Analyze the risks and benefits of genetic engineering to society
5. Describe selection tools for genetic improvement of beef	
6. Describe selection tools for genetic improvement of dairy herds	10C-4: Associate the roles of genetic variation and natural selection with change in organisms over time 10D-9: Analyze the risks and benefits of genetic engineering to society

Animal Science Competencies	Missouri Core Competencies and Key Skills for Science
7. Describe selection tools for genetic improvement of sheep	
8. Describe selection tools for genetic improvement of swine	10C-4: Associate the roles of genetic variation and natural selection with change in organisms over time 10D-9: Analyze the risks and benefits of genetic engineering to society
Unit III - Reproduction	
1. Identify the importance of reproduction in livestock production	10B-4: Describe the structure and function of human reproductive organs
2. Describe the hormonal system in livestock reproduction	
3. Describe the reproductive cycle of common production livestock	10A-2: Distinguish between mitosis and meiosis 10B-4: Describe the structure and function of (human) reproductive organs
4. Sequence the fetal developmental stages of livestock	10B-4: Describe the structure and function of (human) reproductive organs 10C-7: Sequence the developmental stages of the (human) fetus
5. Describe the effects of the environment on the reproductive cycle	10A-7: Describe the significance of the light and dark phases of photosynthesis
6. Describe how management and technology are utilized to affect the reproductive cycle	10C-4: Associate the roles of genetic variation and natural selection with change in organisms over time
Unit IV - Animal Health	
1. Identify the importance of animal health in livestock	
2. Describe aspects of the immune system of domestic livestock	10C-2: Hypothesize how genetic resistance develops from continued exposure to pesticides or antibiotics
3. Describe the diseases of the respiratory system affecting livestock	
4. Describe the diseases of the gastro-intestinal tract in livestock	10B-5: Associate common human diseases with organs affected
5. Describe the diseases of the reproductive system in livestock	
6. Describe the major external and internal parasites of livestock	10A-6: Classify species associations into types of symbiosis: commensalism, mutualism, and parasitism
7. Describe animal health quality assurance programs	

SUGGESTED TEACHING CALENDAR
(in days, one period per day)

		DAYS
Unit I - Nutrition		**50**
1.	Importance of Nutrition to Agriculture	5
2.	Livestock Digestive Systems	7
3.	Energy's Role in Livestock Nutrition	7
4.	Protein's Role in Animal Nutrition	7
5.	Minerals' Role in Animal Nutrition	4
6.	Vitamins' Role in Animal Nutrition	5
7.	Water's Role in Animal Nutrition	5
8.	Environmental Effects on Nutrition	5
9.	Formulating and Blanacing Rations	5
Unit II - Genetics		**40**
1.	Importance of Genetics in Agriculture	4
2.	Basic Building Blocks of Genetics	7
3.	Animal Cell Division	5
4.	Basic Principles of Genetics	8
5.	Tools for Genetic Improvement of Beef	4
6.	Selection Tools for Genetic Improvement of Dairy Cattle	4
7.	Tools for Genetic Improvement of Sheep	4
8.	Selection Tools for Genetic Improvement of Swine	4
Unit III - Reproduction		**30**
1.	Importance of Reproduction in Livestock	6
2.	Reproductive Hormones	5
3.	Reproductive Cycles of Common Livestock	4
4.	Fetal Developmental Stages	4
5.	Effects of the Environment on Reproduction	5
6.	Management and Technology Effects in Reproduction	6
Unit IV - Animal Health		**50**
1.	Importance of Animal Health	7
2.	Immune System of Livestock	7
3.	Respiratory Diseases Affecting Livestock	7
4.	Diseases of the Gastrointestinal Tract	7
5.	Reproductive Diseases in Livestock	7
6.	External and Internal Parasites	7
7.	Quality Assurance Programs	8

ANIMAL SCIENCE
Competency Profile

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale:
3 **Mastered** - can work independently with no supervision
2 **Requires Supervision** - can perform job completely with limited supervision
1 **Not Mastered** - requires instruction and close supervision
N **No Exposure** - no experience or knowledge in this area

3	2	1	N	**A. Nutrition**
				1. Identify the importance of nutrition to agriculture (A001)
				2. Compare and contrast the digestive systems of livestock (A002)
				3. Describe energy's role in nutrition (A003)
				4. Describe protein's role in nutrition (A004)
				5. Describe minerals' role in nutrition (A005)
				6. Describe vitamins' role in nutrition (A006)
				7. Describe the role of water in nutrition (A007)
				8. Describe environmental effects on nutrition (A008)
				9. Formulate a ration for different classes of livestock (A009)

3	2	1	N	**B. Genetics**
				1. Describe the importance of genetics on agriculture (B001)
				2. Describe the basic building blocks of genetics (B002)
				3. Describe animal cell division (B003)
				4. Describe basic principles of genetics (B004)
				5. Describe selection tools for genetic improvement of beef (B005)
				6. Describe selection tools for genetic improvement of dairy herds (B006)
				7. Describe selection tools for genetic improvement of sheep (B007)
				8. Describe selection tools for genetic improvement of swine (B008)

3	2	1	N	**C. Reproduction**
				1. Identify the importance of reproduction in livestock production (C001)
				2. Describe the hormonal system in livestock reproduction (C002)
				3. Describe the reproductive cycle of common production livestock (C003)
				4. Sequence the fetal developmental stages of livestock (C004)
				5. Describe the effects of the environment on the reproductive cycle (C005)
				6. Describe how management and technology are utilized to affect the reproductive cycle (C006)

3	2	1	N	**D. Animal Health**
				1. Identify the importance of animal health in livestock (D001)
				2. Describe aspects of the immune system of domestic livestock (D002)
				3. Describe the diseases of the respiratory system affecting livestock (D003)
				4. Describe the diseases of the gastrointestinal tract in livestock (D004)
				5. Describe the diseases of the reproductive system in livestock (D005)
				6. Describe the major external and internal parasites of livestock (D006)
				7. Describe animal health quality assurance programs (D007)

										Students: **Animal Science** Class/Section:
										A. Nutrition
										1. Identify the importance of nutrition to agriculture (A001)
										2. Compare and contrast the digestive systems of livestock (A002)
										3. Describe energy's role in nutrition (A003)
										4. Describe protein's role in nutrition (A004)
										5. Describe minerals' role in nutrition (A005)
										6. Describe vitamins' role in nutrition (A006)
										7. Describe the role of water in nutrition (A007)
										8. Describe environmental effects on nutrition (A008)
										9. Formulate a ration for different classes of livestock (A009)

										B. Genetics
										1. Describe the importance of genetics on agriculture (B001)
										2. Describe the basic building blocks of genetics (B002)
										3. Describe animal cell division (B003)
										4. Describe basic principles of genetics (B004)
										5. Describe selection tools for genetic improvement of beef (B005)
										6. Describe selection tools for genetic improvement of dairy herds (B006)
										7. Describe selection tools for genetic improvement of sheep (B007)
										8. Describe selection tools for genetic improvement of swine (B008)

										Students: **Animal Science (continued)** Class/Section:
										C. Reproduction
										1. Identify the importance of reproduction in livestock production (C001)
										2. Describe the hormonal system in livestock reproduction (C002)
										3. Describe the reproductive cycle of common production livestock (C003)
										4. Sequence the fetal developmental stages of livestock (C004)
										5. Describe the effects of the environment on the reproductive cycle (C005)
										6. Describe how management and technology are utilized to affect the reproductive cycle (C006)
										D. Animal Health
										1. Identify the importance of animal health in livestock (D001)
										2. Describe aspects of the immune system of domestic livestock (D002)
										3. Describe the diseases of the respiratory system affecting livestock (D003)
										4. Describe the diseases of the gastrointestinal tract in livestock (D004)
										5. Describe the diseases of the reproductive system in livestock (D005)
										6. Describe the major external and internal parasites of livestock (D006)
										7. Describe animal health quality assurance programs (D007)

UNIT I - NUTRITION

Lesson 1: Importance of Animal Nutrition to Agriculture

Objective: The student will be able to identify the importance of nutrition in livestock.

Study Questions

1. **What careers are associated with nutrition?**
2. **Who sets the guidelines for nutrition?**
3. **What information is supplied on feed tags, and what is its purpose?**
4. **What is the economic importance of understanding nutrition?**
5. **What are the general functions which nutrients serve in the animal body?**

References

1. Student Reference
2. Transparency Master
    a) TM 1.1: Example Feed Tag

UNIT I - NUTRITION

Lesson 1: The Importance of Animal Nutrition to Agriculture

TEACHING PROCEDURES

A. Review

Review the nutrition unit in Ag Science I core curriculum.

B. Motivation

1. Have students research occupations associated with animal nutrition and their contributions.

2. Who sets the guidelines for livestock requirements? (not the farmer or the feed store) Why are these guidelines necessary?

3. What is a feed tag? What information is provided on a feed tag? Why are these requirements important to a person who feeds livestock?

4. Why is important to understand animal nutrition? How does it affect your everyday life?

C. Assignment

D. Supervised study

E. Discussion

1. Ask the students what careers they view as nutrition careers and what the educational requirements might be.

What careers are associated with nutrition?

a) More than 20% of the U.S. labor force works in an ag-related occupation. Approximately 540,000 are employed in the meat, poultry and dairy production industry. Careers associated with nutrition are numerous. The careers may be directly or indirectly related to nutrition. They include:
    1) Agricultural instructors
    2) Livestock producers/farmers
    3) Nutrition specialists
    4) Feedlot employees/managers
    5) Feed sales reps
    6) Horse trainers
    7) Feed store managers
    8) Veterinarians
    9) Nutrition researchers

b) Most occupations require a college degree or years of experience. More and more areas are requiring a master's degree or more. Today, most feed sales reps are required to have a college degree.

2. Ask the students who sets the guidelines and determines the recommended nutritional requirements. Relate that Missouri uses national NRC guidelines.

   Who sets the guidelines for nutrition?

   a) The work of research scientists has resulted in greatly improved methods of feeding livestock. Many of the U.S. Agriculture Experiment Stations conduct feeding trials. Results of these experiments relate to the value of feeds and rations under controlled feeding conditions.
   b) The National Research Council of the National Academy of Sciences develops the requirements for different livestock species.
   c) The respective sets of requirements are available in publications specific to each species. Subcommittees on each specie are formed to review the requirements that were set through years of experimentation.
   d) The NRC reviews and/or revises its requirements every several years.

3. Ask the students what information is provided on feed tags.

   What information is supplied on feed tags, and what is its purpose?

   a) Individual states generally regulate the manufacturing and sale of feeds. However, regulations relating to feed additives are made by the federal government. The Association of the American Feed Control Officials has published the "Uniform State Feed Bill," after which many states pattern their regulations. This results in fairly uniform state guidelines regarding the sale and manufacturing of feed.
   b) The feed tag found on a bag of commercial feed is important to the livestock feeder. It contains information about the content of the feed and its proper use. The format and content of the feed tag or label is regulated by state laws.
   c) The tag generally contains the following information.
      1) Net weight
      2) Product name and brand name
      3) Guaranteed analysis of the feed
         (a) Minimum percentage of crude protein
         (b) Maximum or minimum percentage of equivalent protein from nonprotein nitrogen
         (c) Minimum percentage of crude fat
         (d) Maximum percentage of crude fiber
         (e) Minimum and maximum percentages of calcium and salt
         (f) Minimum percentage of phosphorus
         (g) Other minerals
         (h) Vitamin content
      4) When drugs are used as an additive, requirements must be met.
         (a) The word "medicated" must be on the label.
         (b) The purpose of the medication must be stated.
         (c) Directions for use and precautionary statements must be included.
         (d) Active drug ingredients must be listed.
   d) Certain exemptions on labeling are common.
      1) No mineral guarantee is needed *if* no label claims concerning minerals are made *and* the total mineral content is less than 6.5% of the total contents.
      2) No vitamin information is required when the feed contains no claims concerning vitamins or is not being sold as a vitamin supplement.
      3) Crude protein, crude fat and crude fiber guarantees are not needed if the feed is not intended to furnish these substances or if they are a minor part of the total

ingredients. (For example, in drug premixes, mineral or vitamin supplements and molasses)

e) This general description of feed tag labeling is not intended to be a specific guide for a given state. Instead, the Department of Agriculture in each state establishes committees to set state standards. The feed laws, rules and regulations of each state should be considered to determine specific requirements for that state.

4. Have the students list what they feel are the assets of understanding nutrition.

What is the economic importance of understanding nutrition?

a) Agriculture is the largest industry in the U.S.
   1) The total assets of agriculture exceed one trillion dollars.
   2) Production of livestock is an important part of the total agriculture industry.
   3) About 50% of farm cash receipts comes from the sale of livestock and livestock products.
b) The cost of feed is 50-75% of the total cost of raising livestock.
   1) Careful attention to animal nutrition can help reduce feed costs and thus increase the potential profit from livestock.
   2) The lowest cost feed ration may not be the most profitable. One must also consider feeding efficiency and nutrition value when selecting rations.
c) Estimated feed costs for different species vary somewhat.
   1) Swine = 65-80% of total costs
   2) Poultry = 55-65%
   3) Dairy = 50-60%
   4) Finishing beef cattle = 70%
   5) Finishing lambs = 50%

5. Ask the students how nutrients found in feed help the animal.

What are the general functions that nutrients serve in the animal body?

a) There are three general functions that nutrients serve.
   1) Maintenance--maintain basic life processes without any work or production
      (a) Heat to maintain body temperature
      (b) Energy for vital functions and a minimum amount of movement
      (c) Small amounts of protein, minerals and vitamins
   2) Growth (assimilation of tissue)
   3) Reproduction
b) There are also functions which are specific to the purpose of the animal.
   1) Finishing/fattening for market
   2) Fitting for show
   3) Production
      (a) Meat
      (b) Milk
      (c) Eggs
      (d) Wool and mohair
   4) Work
      (a) Horses
      (b) Movement in environment

F. Other activities

1. Have the students research income for a nutrition-related career.

2. Have a local feed sales rep or feed store manager talk to the class about careers, feed requirements, and the importance of understanding nutrition.

3. Have the students bring in feed tags from feed used at home. Compare and contrast the information listed.

4. Tour an animal nutrition research facility.

G. Conclusion

Nutritionists formulate livestock rations to provide the nutrients needed by animals for maintenance and production. Producers are rarely interested in just maintaining animals, yet the maintenance requirements must be met before animals will provide any productivity.

H. Competency

Identify the importance of nutrition to agriculture.

I. Answers to Evaluation

1. d
2. b
3. c
4. c
5. Maintenance, growth and reproduction
6. Any of the careers listed in the lesson or discussed in class
7. Any of the requirements listed in the lesson

UNIT I - NUTRITION Name________________

Lesson 1: The Importance of Nutrition to Agriculture Date________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Who sets the nutritional requirements for domestic animals?

   a. Farmers
   b. University nutrition specialists
   c. Feed manufacturers
   d. National Feed Council

2. Who sets regulations for feed tags?

   a. Feed manufacturers
   b. Individual states
   c. U.S. Department of Agriculture
   d. Feed stores

3. The cost of feed is _______% of the total cost in livestock production.

   a. 10-20
   b. 25-40
   c. 50-75
   d. 100

4. How much of total farm cash receipts do livestock sales make up?

   a. 10%
   b. 25%
   c. 50%
   d. 80%

Complete the following short answer questions.

5. List the three general functions that nutrients serve in the animal.

6. List four careers associated with nutrition.

7. List four items required to be on a feed tag.

Example Feed Tag

NET WEIGHT 50 LBS.

SUPER COW
16% TEXTURED

GUARANTEED ANALYSIS

Crude Protein, not less than	16.0%
Crude Fat, not less than	3.0%
Crude Fiber, not more than	7.5%

INGREDIENTS

Grain Products, Processed Grain By-Products, Plant Protein Products, Animal Protein Products, Cane Molasses, Salt, Calcium Carbonate, Dicalcium Phosphate, Manganese Oxide, Ferrous Sulfate, Copper Sulfate, Magnesium Oxide, Potassium Chloride, Cobalt Carbonate, Zinc Oxide, Ethylenediamine Dihydriodide, Sodium Selenite, Lignin Sulfonate and Sodium Bentonite (pellet binders), Vitamin A Acetate, D-Activated Animal Sterol (source of Vitamin D-3), Vitamin E Supplement, Niacin Supplement, Dried Lactobacillus Acidophilus Fermentation Products, Zinc Methionine.

FEEDING DIRECTIONS

Feed Super Cow 16% Textured as a high-energy supplement to excellent legume hay or haylage or lush legume-grass pasture when used as the only source of roughage for the lactating cow. Feed 1 lb. of this feed for each 2-3 lbs. of milk produced.

5624

Manufactured by
MFA INCORPORATED
Columbia, MO 65201

378X1F 1WR56244

UNIT I - NUTRITION

Lesson 2: Livestock Digestive Systems

Objective: The student will be able to compare and contrast the different digestive systems in livestock.

Study Questions

1. **How is food digested in a ruminant?**
2. **How is food digested in a nonruminant?**
3. **How is food digested in a modified nonruminant?**
4. **How is food digested in poultry?**

References

1. Student Reference
2. Transparency Masters
    - a) TM 2.1: Comparison of Digestive System Parts
    - b) TM 2.2: Digestive System Parts of a Ruminant
    - c) TM 2.3: Digestive System Parts of a Nonruminant
    - d) TM 2.4: Digestive System Parts of an Avian

UNIT I - NUTRITION

Lesson 2: Livestock Digestive Systems

TEACHING PROCEDURES

A. Review

1. Review the previous lesson on the importance of animal nutrition.
2. Reinforce that ruminants include cattle, sheep and goats; nonruminants include swine and humans; modified nonruminants include horses and rabbits; and poultry (avian) include ducks, chickens, and turkeys.

B. Motivation

1. Are there any similarities between human and livestock digestive systems? The human digestive system is very similar to the nonruminant's digestive system (such as swine). They consist of a mouth, esophagus, simple stomach, small intestine, large intestine, and anus. They both use these parts to mechanically and chemically breakdown food for absorption.
2. How long is the digestive tract in humans? How long is the digestive tract in swine? From mouth to anus, the digestive tract in a human is 30 feet in length. The digestive tract in swine is about 80 feet in length. In hogs, this added length permits some absorption in the large intestine, while little or no absorption occurs in the large intestine of humans.

C. Assignment

D. Supervised study

E. Discussion

1. Ask students about the differences between the digestive systems of ruminants and nonruminants. (A ruminant animal has a four-compartment stomach, where each compartment serves a different function in the digestion of roughage. A nonruminant animal has one stomach, which cannot digest roughage.)

   How is food digested in a ruminant?

   a) Parts in the ruminant digestive system
      1) Mouth
      2) Esophagus
      3) Rumen
      4) Reticulum
      5) Omasum
      6) Abomasum
      7) Liver
      8) Gallbladder
      9) Pancreas
      10) Duodenum
      11) Small intestine
      12) Colon
      13) Cecum

- 14) Rectum

- b) Functions of digestion in ruminants
  - 1) Mouth--Three physical processes occur in the mouth.
    NOTE: Same functions as nonruminants and modified nonruminants
    - (a) Prehension--the act of bringing food into the mouth
    - (b) Mastication--the act of chewing food (Saliva is added and enzymatic digestion begins.)
    - (c) Deglutition--the act of swallowing
  - 2) Esophagus
    NOTE: Same functions for all classes of livestock
    - (a) Pharynx--structure which controls the passage of air and feed
    - (b) The passageway for food and water from mouth to stomach
  - 3) Reticulum and rumen
    - (a) Microorganisms (bacteria and protozoa) are present to aid in digestion.
    - (b) Fatty acids are produced and absorbed.
    - (c) Vitamins K, C and B-complex are synthesized.
    - (d) Muscular action stirs and mixes food and water, which aids in digestion.
  - 4) Omasum
    - (a) Absorbs water
    - (b) Aids in grinding of food
    - (c) Absorbs volatile fatty acids
  - 5) Abomasum
    - (a) This is considered the "true stomach" in of ruminants.
    - (b) Digestive juices containing acids and enzymes are added, which increase the moisture content of food.
    - (c) A small percentage of feed protein (the hard-to-digest part) is digested here.
  - 6) Pancreas
    NOTE: Same functions as nonruminants, modified nonruminants, and poultry
    - (a) Endocrine gland secretes hormones such as insulin and glucagon.
    - (b) Exocrine gland secretes fluids necessary for digestion.
  - 7) Liver
    NOTE: Same functions as nonruminants and modified nonruminants
    - (a) Secretion of bile, which emulsifies fat
    - (b) Vitamin storage
    - (c) Detoxification of harmful compounds
    - (d) Metabolism of proteins, carbohydrates, and lipids (fats)
    - (e) Storage of carbohydrates when needed
    - (f) Destruction of red blood cells
    - (g) Urea formation
    - (h) Formation of plasma proteins
    - (i) Inactivation of polypeptide hormones
  - 8) The gallbladder stores bile.
    NOTE: Same functions as nonruminants and avians
  - 9) Duodenum
    - (a) Bile and pancreatic fluids are stored here.
    - (b) Fats are emulsified here.
    - (c) Enzymes in the pancreas aid in breaking down carbohydrates and proteins.
  - 10) Small intestine
    - (a) Vitamins and minerals are absorbed into the bloodstream.
    - (b) Proteins (80%) are absorbed here.
    - (c) Lipids (fats) are also absorbed here.
  - 11) Cecum and colon (large intestine)

        (a) Fiber (5 to 15%) is digested in the cecum.
        (b) The majority of water is absorbed in the colon, which causes fecal formation.
        (c) Mucus is added to feces for lubrication.
        (d) The mixture still remains neutral.

2. Ask students about the similarities between the digestive systems of ruminants and nonruminants.

How is food digested in a nonruminant?

- a) Parts in the nonruminant digestive system
    - 1) Mouth
    - 2) Esophagus
    - 3) Stomach
    - 4) Liver
    - 5) Gallbladder
    - 6) Pancreas
    - 7) Duodenum
    - 8) Small intestine
    - 9) Colon
    - 10) Cecum
    - 11) Rectum
- b) Functions of digestion in nonruminants
    - 1) Mouth--Three physical processes occur in the mouth.
      NOTE: Same functions as ruminants and modified nonruminants
        - (a) Prehension--the act of bringing food into the mouth
        - (b) Mastication--the act of chewing food (Saliva is added and enzymatic digestion begins.)
        - (c) Deglutition--the act of swallowing
    - 2) Esophagus
      NOTE: Same functions for all classes of livestock
        - (a) Pharynx--structure which controls the passage of air and food
        - (b) The passageway for food and water from mouth to stomach
    - 3) Stomach
        - (a) Food is mixed with acids and enzymes; this mixture becomes acidic in nature.
        - (b) Fats are partially broken down.
        - (c) Digestion begins on proteins.
        - (d) Carbohydrates move through the stomach at a faster rate than other nutrients.
    - 4) Pancreas
      NOTE: Same functions as ruminants, modified nonruminants, and poultry
        - (a) Endocrine gland function is to secrete hormones such as insulin and glucagon.
        - (b) Exocrine gland secretes fluids necessary for digestion.
    - 5) Liver
      NOTE: Same functions as ruminants and modified nonruminants
        - (a) Secretion of bile, which emulsifies fat
        - (b) Vitamin storage
        - (c) Detoxification of harmful compounds
        - (d) Metabolism of proteins, carbohydrates, and lipids (fats).
        - (e) Storage of carbohydrates
        - (f) Destruction of red blood cells

        (g) Urea formation
        (h) Formation of plasma proteins
        (i) Inactivation of polypeptide hormones
    6) The gallbladder stores bile.
    NOTE: Same functions as ruminants and avians
    7) Duodenum
        (a) Food mixture becomes a neutral mixture with the addition of alkaline enzymes.
        (b) Emulsification of fats by bile makes fats soluble in water.
        (c) Further breakdown of proteins and carbohydrates occurs.
    8) Small intestine
        (a) Digested nutrients are absorbed into the bloodstream.
        (b) Peristalsis is the coordinated contraction and relaxation of smooth muscles to create unidirectional movement of food.
    9) Cecum and colon (large intestine)
        (a) The cecum has a very limited function but does contain microorganisms.
        (b) Water is absorbed in the colon; fecal formation occurs.
        (c) Mucus is added to feces to provide lubrication.
        (d) The mixture remains neutral.

3. Encourage discussion about the similarities between nonruminants and modified nonruminants. (The only real difference is an active cecum in the modified nonruminant.)

How is food digested in a nonruminant?

a) Parts in the modified nonruminant digestive system
    1) Mouth
    2) Esophagus
    3) Stomach
    4) Liver
    5) Pancreas
    6) Duodenum
    7) Colon
    8) Cecum
    9) Rectum
b) Functions of digestion in modified nonruminants
    1) Mouth--Three physical processes occur in the mouth.
    NOTE: Same functions as ruminants and nonruminants
        (a) Prehension--the act of bringing in food into the mouth
        (b) Mastication--the act of chewing food (Saliva is added and enzymatic digestion begins.)
        (c) Deglutition--the act of swallowing
    2) Esophagus
    NOTE: Same functions for all classes of livestock
        (a) Pharynx--the structure which controls the passage of air and food
        (b) The passageway for food and water from the mouth to the stomach
    3) Stomach
        (a) Food is mixed with acids and enzymes; this mixture becomes acidic in nature.
        (b) Fats are partially broken down.
        (c) Digestion begins on proteins.
        (d) Carbohydrates move through the stomach at a faster rate than other nutrients.
    4) Pancreas

NOTE: Same functions as ruminants, nonruminants, and poultry
- (a) Endocrine gland secretes hormones such as insulin and glucagon.
- (b) Exocrine gland secretes fluids necessary for digestion.

5) Liver

NOTE: Same functions as ruminants and nonruminants
- (a) Secretion of bile
- (b) Vitamin storage
- (c) Detoxification of harmful compounds
- (d) Metabolism of proteins, carbohydrates, and lipids
- (e) Storage of carbohydrates
- (f) Destruction of red blood cells
- (g) Urea formation
- (h) Formation of plasma proteins
- (i) Inactivation of polypeptide hormones

6) Duodenum
- (a) Food mixture becomes a neutral mixture with the addition of alkaline enzymes.
- (b) Emulsification of fats by bile makes fats soluble in water.
- (c) Further breakdown of proteins and carbohydrates occur.

7) Small intestine
- (a) Digested nutrients of concentrates are absorbed into the bloodstream.
- (b) Peristalsis is the coordinated contraction and relaxation of smooth muscles to create unidirectional movement of food.

8) Cecum
- (a) Quite functional and much larger than most nonruminant animals
- (b) Digestion of roughage takes place here.
- (c) Contains microorganisms to aid in digestion of roughage

9) Colon
- (a) The majority of the water is absorbed in the colon; fecal formation occurs.
- (b) Mucus is added to feces to provide lubrication.
- (c) The mixture remains neutral.

4. Point out that the digestive system of poultry is considerably different than those of the three groups discussed so far.

How is food digested in poultry?

a) Parts in the avian digestive system
- 1). Mouth
- 2) Esophagus
- 3) Crop
- 4) Proventriculus
- 5) Gizzard
- 6) Liver
- 7) Gallbladder
- 8) Pancreas
- 9) Small intestine
- 10) Large intestine
- 11) Ceca
- 12) Cloaca
- 13) Vent

b) Functions of digestion in poultry
- 1) Mouth--*Two* physical processes occur in the mouth.
  - (a) Prehension--the act of bringing in food into the mouth

    - (b) Deglutition--the act of swallowing
- 2) Esophagus
  NOTE: Same functions for all classes of livestock
    - (a) Pharynx--the structure which controls the passage of air and food
    - (b) The passageway for food and water from the mouth to the crop
- 3) Crop
    - (a) Storage of food
    - (b) Mucus is secreted and added to the food, which softens and lubricates it.
- 4) In the proventriculus, gastric fluids are secreted and added to ingested food.
- 5) Gizzard
    - (a) This muscular organ aids in digestion by mechanically mixing and grinding food.
    - (b) Gastric fluids are mixed with food.
- 6) Pancreas
  NOTE: Same functions as ruminants, nonruminants, and modified nonruminants
    - (a) Endocrine gland secretes hormones such as insulin and glucagon.
    - (b) Exocrine gland secretes enzymes necessary for digestion.
- 7) Liver
    - (a) Secretion of bile
    - (b) Vitamin storage
    - (c) Detoxification of harmful compounds
    - (d) Metabolism of proteins, carbohydrates, and lipids
    - (e) Storage of carbohydrates
    - (f) Destruction of red blood cells
    - (g) Formation of plasma proteins
    - (h) Inactivation of polypeptide hormones
- 8) The gallbladder stores bile.
  NOTE: Same functions as ruminants and nonruminants
- 9) Small intestine movements
    - (a) Pendular motion--Shortening and lengthening of the intestine create a mixing motion.
    - (b) Segmentation contractions--Ringlike contractions at regular intervals create a mixing motion.
    - (c) Peristalsis--The coordinated contraction and relaxation of smooth muscles create unidirectional movement of food.
    - (d) Digested nutrients are absorbed into the bloodstream.
- 10) Ceca
    - (a) Ceca is the plural form of cecum.
    - (b) This blind-ended tube is found at the junction of the small intestine and the large intestine.
- 11) The colon (large intestine) does not play a significant role in digestion, except for water absorption.
- 12) In the cloaca, urinary and fecal materials are mixed together before leaving the body through the vent.

F. Other activities

1. Obtain a digestive tract from a slaughter house to show the movement of food through the digestive system.

2. Activities on salivary digestion, gastric digestion, pancreatic digestion, and digestion of fat are available from:

"Digestive Systems of Domesticated Animals" (#8833-C). *Agriscience 332H: Advanced Animal Science.* College Station, TX: Instructional Materials Service, Texas A&M University, 1990.

G. Conclusion

Understanding livestock digestive systems is critical to success of a producer or another in a related nutrition occupations. The person who can apply nutrition utilization to a situation can greatly improve the profit capability of an operation or business.

H. Competency

Compare and contrast the digestive systems of livestock.

I. Answers to Evaluation

1. h
2. b
3. a
4. g
5. e
6. c
7. j
8. k
9. i
10. d
11. b
12. g
13. d
14. c
15. i
16. k
17. a
18. j
19. f
20. e
21. a
22. b
23. a
24. b
25. d
26. c
27. b
28. c

29-46. Refer to TM 2.1 for answers. (section worth 72 points)

UNIT I - NUTRITION Name________________

Lesson 2: Livestock Digestive Systems Date________________

EVALUATION

Match parts on the right with functions of the ruminant digestive system on the left.

___ 1. Where saliva is mixed with food

___ 2. Where a majority of water is absorbed

___ 3. "True stomach"

___ 4. Detoxification of harmful compounds

___ 5. Storage of bile

___ 6. Emulsification of fats

___ 7. Where B-complex vitamins are synthesized

___ 8. Where minerals are absorbed

___ 9. Location of endocrine and exocrine glands

___ 10. Where the pharynx is located

a. Abomasum

b. Colon

c. Duodenum

d. Esophagus

e. Gallbladder

f. Large intestine

g. Liver

h. Mouth

i. Pancreas

j. Rumen

k. Small intestine

Match parts with functions of the poultry digestive system.

___ 11. Where fecal and urinary materials are mixed

___ 12. Storage of vitamins

___ 13. Passageway from mouth to crop

___ 14. Where food is softened and lubricated

___ 15. Where insulin is secreted

___ 16. Location of pendular motion

___ 17. Blind-ended tube between small intestine and large intestine

___ 18. Where gastric fluids are secreted

___ 19. Where mixing and grinding of food occurs

___ 20. Storage of bile

a. Ceca

b. Cloaca

c. Crop

d. Esophagus

e. Gallbladder

f. Gizzard

g. Liver

h. Mouth

i. Pancreas

j. Proventriculus

k. Small intestine

Circle the letter that corresponds to the best answer.

21. Which describes the coordinated contraction and relaxation of smooth muscles to create unidirectional movement of food?

    a. Peristalsis
    b. Pendular
    c. Segmentation
    d. Mastication

22. In the small intestine of poultry, which mixing movement is caused by shortening and lengthening the intestine?

    a. Peristalsis
    b. Pendular
    c. Segmentation
    d. Mastication

23. In poultry, which mixing movement is caused by ring-like contractions at regular intervals in the intestine?

    a. Segmentation
    b. Mastication
    c. Deglutition
    d. Prehension

24. Which describes the act of chewing food?

    a. Segmentation
    b. Mastication
    c. Deglutition
    d. Prehension

25. Which describes the act of bring food into the mouth?

    a. Segmentation
    b. Mastication
    c. Deglutition
    d. Prehension

26. Where are red blood cells destroyed?

    a. Pharnyx
    b. Pancreas
    c. Liver
    d. Gallbladder

27. Which structure which controls the passage of air and food?

    a. Liver
    b. Pharnyx
    c. Pancreas
    d. Gallbladder

28. Where is urea formed?

a. Pharnyx
b. Pancreas
c. Liver
d. Gallbladder

Place a check in each part of the table that pertains to that class of animal. (The first one has been done for you as an example.)

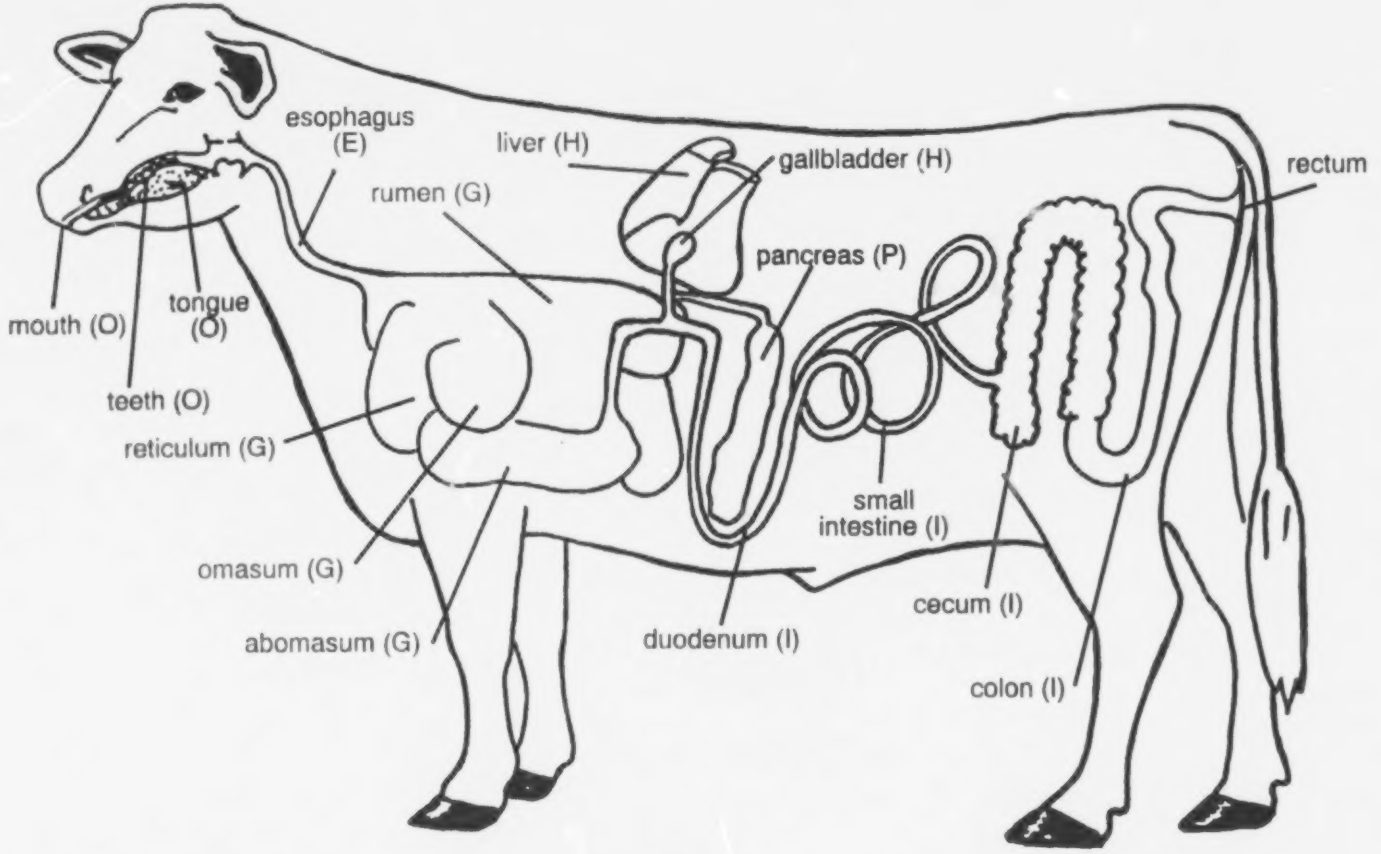
Body part	**Ruminants**	**Nonruminants**	**Mod. non-ruminants**	**Poultry (avian)**
Oral Mouth	✓	✓	✓	✓
Esophageal 29. Esophagus				
Gastric 30. Rumen				
31. Reticulum				
32. Omasum				
33. Abomasum				
34. Stomach				
35. Crop				
36. Proventriculus				
37. Gizzard				
Pancreatic 38. Pancreas				
Hepatic 39. Liver				
40. Gallbladder				
Intestinal 41. Duodenum				
42. Colon				
43. Cecum				
44. Small intestine				
45. Cloaca				
46. Rectum				

Comparison of Digestive System Parts

NOTE: Shaded areas show that those animals have that part.

Body part	Ruminants	Non-ruminants	Mod. non-ruminants	Poultry (avian)
Oral Mouth	▨	▨	▨	▨
Esophageal Esophagus	▨	▨	▨	▨
Gastric Rumen	▨			
Reticulum	▨			
Omasum	▨			
Abomasum	▨			
Stomach		▨	▨	
Crop				▨
Proventriculus				▨
Gizzard				▨
Pancreatic Pancreas	▨	▨	▨	▨
Hepatic Liver	▨	▨	▨	▨
Gallbladder	▨	▨		▨
Intestinal Duodenum	▨	▨	▨	
Colon	▨	▨	▨	▨
Cecum/ceca	▨	▨	▨	▨ (ceca)
Small intestine	▨	▨		▨
Cloaca				▨
Rectum/vent	▨	▨	▨	▨ (vent)

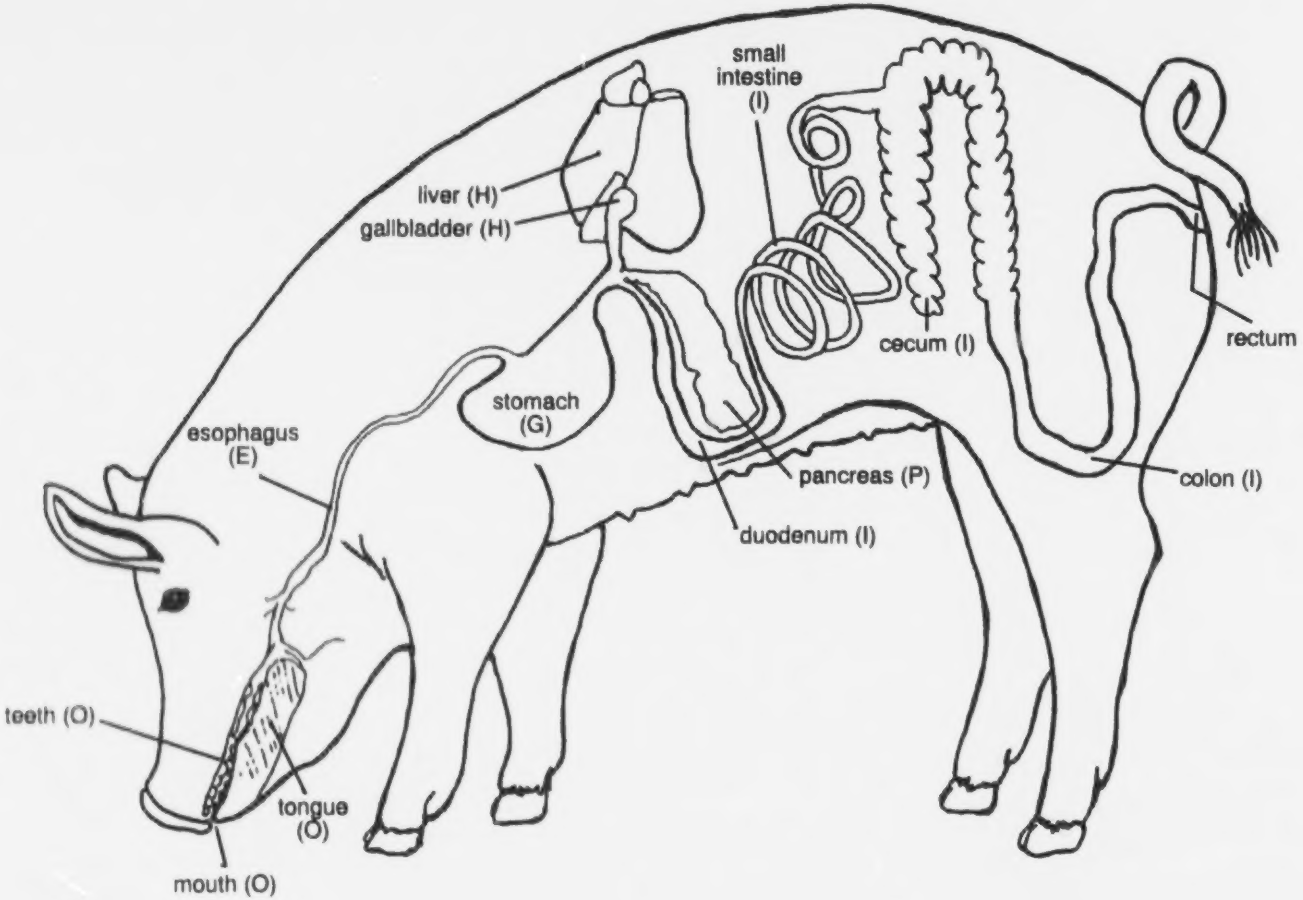
Digestive System Parts of a Ruminant


esophagus (E)
liver (H)
gallbladder (H)
rumen (G)
rectum
pancreas (P)
mouth (O)
tongue (O)
teeth (O)
reticulum (G)
small intestine (I)
omasum (G)
cecum (I)
abomasum (G)
duodenum (I)
colon (I)

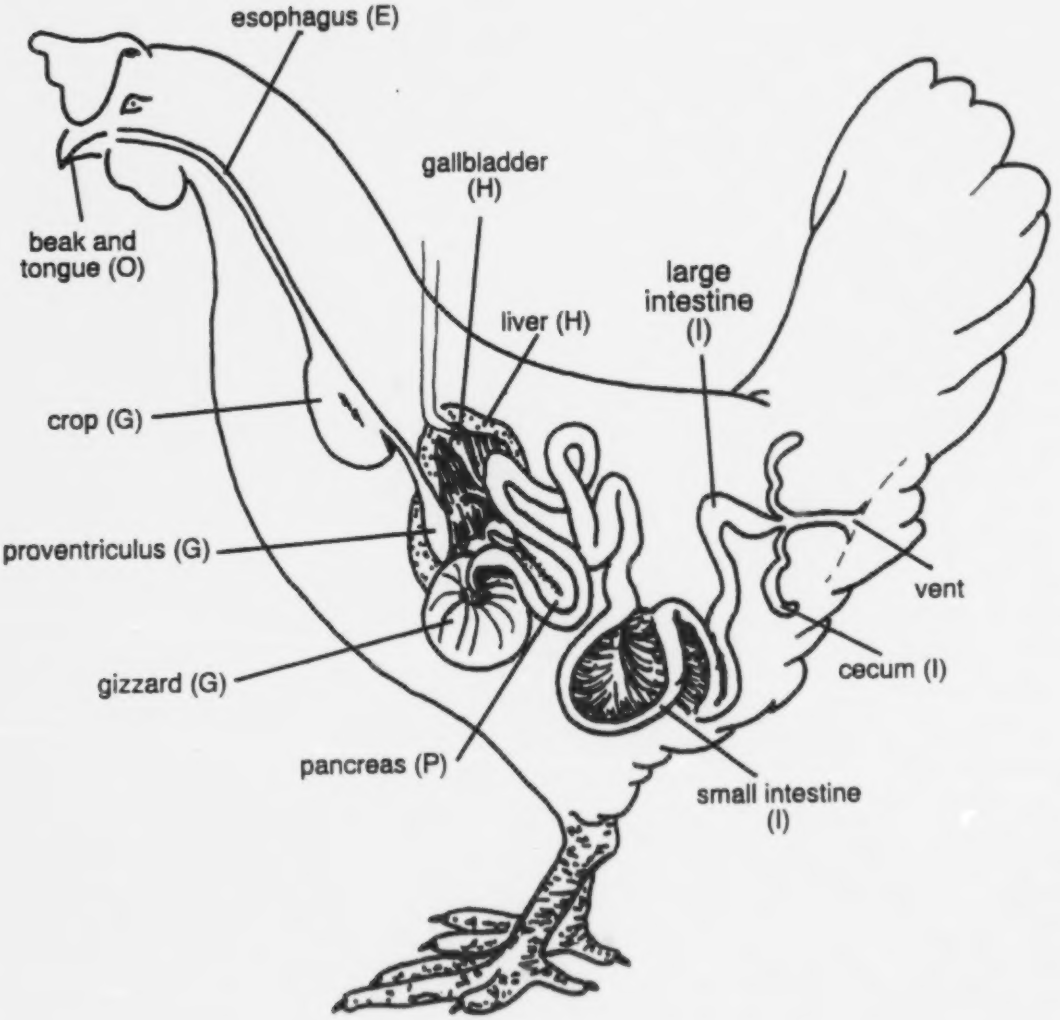
I-27

TM 2.2

Digestive System Parts of a Nonruminant


small intestine (I)
liver (H)
gallbladder (H)
cecum (I)
rectum
stomach (G)
esophagus (E)
pancreas (P)
colon (I)
duodenum (I)
teeth (O)
tongue (O)
mouth (O)

Digestive System Parts of an Avian


esophagus (E)
beak and tongue (O)
gallbladder (H)
liver (H)
large intestine (I)
crop (G)
proventriculus (G)
vent
gizzard (G)
cecum (I)
pancreas (P)
small intestine (I)

UNIT I - NUTRITION

Lesson 3: Energy's Role in Livestock Nutrition

Objective: The student will be able to describe the function of energy in livestock nutrition.

Study Questions

1. **What are the basic functions of energy in the body?**
2. **How are carbohydrates and fats related to energy?**
3. **Where are carbohydrates and fats absorbed in the digestive system?**
4. **What are the sources of energy for ruminants and nonruminants?**
5. **What are deficiency and toxic effects of carbohydrates and fats?**

References

1. Animal Science

UNIT I - NUTRITION

Lesson 3: Energy's Role in Livestock Nutrition

TEACHING PROCEDURES

A. Review

1. Review the previous lesson on digestive systems of livestock.

B. Motivation

1. What are two sources of energy? (carbohydrates and fats)

2. What are some signs of energy deficiencies in humans?

   a) Always feeling rundown can be a sign of a lack of carbohydrates and fats.
   b) Insufficient fats in the body cause a lack of fat-soluble vitamins.

3. What are sources of carbohydrates and fats for humans?

   a) Carbohydrates--breads, pasta, sugars, cereals, fresh fruit, starchy vegetables
   b) Fats--dairy products, meats, and oils

4. What are the signs of excess consumption of energy in humans? (Excess carbohydrates are changed to fat and stored in the body as excess body weight. Excess weight causes other problems, such as heart conditions and high blood pressure.)

C. Assignment

D. Supervised study

E. Discussion

1. Ask the students to discuss the functions of energy in the body. Discuss why it is important to understand energy requirements.

   What are the basic functions of energy in the body?

   a) Maintenance of life
      1) Controls basal metabolism, such as beating of the heart, blood pressure maintenance, nerve impulse transmission, breathing, and internal organ work
      2) Keep muscles in state of tension
      3) Supply fuel to maintain body temperature
   b) Growth and production
      1) Fattening
      2) Lactation--milk production
      3) Development of a fetus
      4) Reproduction
      5) Work

2. Ask the students for the two types of energy sources. How do they differ?

How are carbohydrates and fats related to energy?

- a) Carbohydrates and lipids (fats and oils) are the major sources of energy in livestock rations.
- b) Carbohydrates--most important
  - 1) Readily available
  - 2) Easily digested in greatest quantities in most feeds
  - 3) Generally lower in cost
- c) Fats and oils
  - 1) It is difficult to store feeds high in fat content during warm weather because feeds tend to become rancid (bad odor and flavor).
  - 2) Feeds become less palatable, and animals are reluctant to eat them.
  - 3) Fatty feeds may make the animal sick.
- d) Carbohydrates are organic compounds made of carbon (C), hydrogen (H), and oxygen (O).
  - 1) Plants produce carbohydrates by photosynthesis.
    - (a) Energy from the sun, plus water and carbon dioxide, produce glucose and oxygen.
    - (b) Carbohydrates include:
      - (1) Starch
      - (2) Sugars
      - (3) Hemicellulose
      - (4) Cellulose
      - (5) Pectins
      - (6) Gums
      - (7) Lignins
    - (c) Most carbohydrates are combinations of saccharides or sugars.
    - (d) One way carbohydrates are classified is by the number of molecules of sugars they contain. For example, monosaccharides contain only one sugar molecule.
  - 2) In digestion, carbohydrates in feed are changed into simpler forms.
    - (a) Glucose levels in the bloodstream of animals are maintained at a level of 0.05-0.1 percent concentration.
    - (b) Because glucose can be used by all animals, it is the most important sugar found in the body.
  - 3) Two groups of carbohydrates
    - (a) Fiber: contains hard-to-digest hemicellulose, cellulose, and lignin
    - (b) Nitrogen-free extract (NFE)
      - (1) Includes starches and sugars
      - (2) Plants store energy as starch in grain; grains have a high feeding value since starch is easily digested.
  - 4) Digestion of fiber is related to the presence or absence of bacteria in the digestive system.
    - (a) Ruminants
      - (1) High bacteria population in the rumen
      - (2) Make use of energy from the fiber portion of the ration
      - (3) Bacterial action breaks fiber down into volatile fatty acids absorbed through the rumen wall
      - (4) Roughage in a ruminant's ration can provide much of the maintenance energy needed by the animal

- (b) Nonruminants, modified nonruminants, and avians
  - (1) No rumen
  - (2) Low bacteria population in stomach and intestines
  - (3) Less ability to utilize energy from fiber
  - (4) For mature breeding animals, increase the level of fiber in the ration to prevent excessive weight gain.
  - (5) Fiber assures adequate elimination of waste products (keeps animals "regular").

- e) Lipids (fats and oils) are made up of carbon, hydrogen, and oxygen.
  - 1) Lipids have higher carbon and hydrogen levels than carbohydrates, but lower oxygen levels.
  - 2) Lipids supply 2.25 times as much energy as an equal amount of carbohydrates.
  - 3) At body temperature, fats are solids and oils are liquids.
  - 4) Fats are composed of two units--fatty acids and glycerol.
    - (a) Fatty acids consist of a carbon chain, 2-20 carbons in length, which contains a carboxyl group (COOH).
      - (1) Saturated fatty acids contain carbons attached with all single bonds.
      - (2) Unsaturated fatty acids contain carbons attached by double bonds. These double bond sites are chemically reactive; as a result, they are less stable than saturated.
      - (3) As the number of double bonds increases, the melting point of fat is lowered and the fats become softer (oils).
    - (b) Glycerol is the second constituent of fat.
    - (c) Fats are formed when one glycerol combines with three fatty acids to form a triglyceride.
  - 5) Rancidity may be a problem with both saturated and unsaturated fats. Oxidative rancidity occurs only in unsaturated fats.
    - (a) Requires presence of oxygen
    - (b) Alters flavor, odor, and nutritional value
    - (c) Favored by moist conditions
    - (d) Part of hyperoxide formation, which promotes aging and destroys the immune system
    - (e) Destroys essential fatty acids
    - (f) Prevented with antioxidants (Vitamin E) and storing fats in cool environment
  - 6) Three fatty acids are considered dietary essential nutrients since they are not synthesized by nonruminant animals. However, these fatty acids are synthesized by microorganisms in the rumen.
    - (a) Linoleic acid
    - (b) Linolenic acid
    - (c) Arachidonic acid
  - 7) Storage of fats in the body
    - (a) Marbling is fat stored in muscle tissue.
    - (b) Fat stored in adipose (fatty) tissue contains reserve energy, which can help sustain life for a while if feed supplies are cut off.
  - 8) Uses of fats in feed
    - (a) Raise energy level
    - (b) Improve flavor, texture, and palatability
    - (c) Reduce dustiness
    - (d) Improve glossiness of hair coat in show animals
  - 9) Guidelines for fat content in feed
    - (a) Ruminants: no more than 3-5 percent
    - (b) Nonruminants: no more than 15-20 percent

3. Ask the students for ideas on what happens to nutrients to make them usable by the animal's body. (Refer to Lesson 2, if necessary.)

Where are carbohydrates and fats absorbed in the digestive system?

- a) Carbohydrates (ruminants and nonruminants)
  - 1) Mostly in the small intestine
    - (a) Starches and sugars are converted to glucose, fructose, and galactose when digested.
    - (b) Crude fiber is converted to short, chained fatty acids or glucose by digestion.
    - (c) By osmosis, nutrients pass into the blood capillaries through semipermeable membranes of the digestive tract, then through the liver into the bloodstream.
  - 2) Some in the large intestine
- b) Fats (ruminants and nonruminants)
  - 1) Fats are digested into fatty acids and glycerols called chyle.
  - 2) Chyle is absorbed by lacteal (lymphatic vessels) and carried through the lymphatic system.

4. Ask students to list sources of readily available carbohydrates and fats.

What are the sources of energy for ruminants and nonruminants?

- a) Grains (major source)
  - 1) Shelled corn
    - (a) Highest energy feed available
    - (b) Economical and superior source of energy for livestock
  - 2) Oats
    - (a) Contains 85 percent of the energy of shelled corn
    - (b) Higher in crude protein; add fiber and bulk to rations
    - (c) Helps maintain rumen functions in ruminants
  - 3) Barley
  - 4) Grain sorghum (similar to shelled corn)
  - 5) Wheat
- b) Roughage
  - 1) Roughage supplies some energy needs in livestock rations but is not a concentrated source.
  - 2) The value of forages is highly dependent upon time of harvest.
  - 3) As the plant matures, crude fiber content increases; this lowers the digestibility of the feed.
    - (a) Corn silage
    - (b) Hay
    - (c) Pastures
- c) Fats
  - 1) Feed-grade animal fat is a byproduct of packing, poultry processing, and animal rendering plants.
  - 2) Animal fat is an economical source of energy used in manufacturing commercially mixed feeds.

5. Ask students to list signs of a lack of energy in an animal's diet.

What are deficiency and toxic effects of carbohydrates and fats?

a) Deficiency symptoms
  1) Slower growth in the young
  2) Delay of onset of puberty
  3) Decrease in milk yield in lactating females
  4) Shortened lactation period
  5) Loss of body weight
  6) Reduced fertility and delayed estrus
  7) Higher mortality rates
  8) Lowered resistance to disease and parasites

b) Toxic effects
  1) Obesity
    (a) Decreased fertility
    (b) Delayed estrus
  2) Ketosis
    (a) Ketosis occurs when an animal has a higher energy demand (such as lactating dairy cattle) and a low supply of carbohydrates.
    (b) To meet the energy demand, the animal increases the metabolism of fats.
    (c) The increased fat metabolism rate overloads the liver with ketone acids.
    (d) Ketone acids can provide energy for muscles but **cannot** provide energy for the brain.
    (e) If the situation is not corrected, glucose blood levels drop so low that the animal collapses, goes into a coma, and dies.
    (f) This often happens to the best milk cows because of high energy requirements.

F. Other activities

1. Have students bring in feed tags from various commercial feeds and compare the energy values.

2. Visit a local feed mill or elevator. Ask the operator to explain how they formulate feeds and determine the energy nutrients to include in them.

3. Have students keep track of the foods they eat for a week, and have them determine which of the foods would be considered energy nutrients.

4. For quick response, feed small animals (especially chickens) different protein levels to see the results.

5. Consider using a kit to demonstrate the solubility and saturation of fats and carbohydrates. Carolina Biological Supply Co. (800/334-5551) has two kits: "Introduction to Properties of Lipids" and "Introduction to Analysis of Carbohydrates."

G. Conclusion

Fuel is supplied to the body by energy nutrients. The major sources of energy in livestock rations are carbohydrates and fats. Energy is used for digestion; absorption of nutrients; breathing; heart action; movement of muscles; production of milk, eggs, wool, and mohair; waste formation and excretion; and to supply heat to maintain body temperature. Some feed energy is lost through the feces, urine, and gases produced in the body. Excess energy not used to sustain life is stored as body fat.

H. Competency

Describe energy's role in nutrition.

I. Answers to Evaluation

1. Maintenance of life; growth and production
2. Carbohydrates and fats
3. Carbon, hydrogen, and oxygen
4. Fiber and nitrogen-free extract (NFE)

5. Three of the following:
   a) Raise energy level of feed
   b) Improve flavor and texture of feed
   c) Reduce dustiness of feed
   d) Improves glossiness of hair coat

6. Carbohydrates are absorbed through the liver and then the bloodstream, while fats are first absorbed through the lymphatic system before entering the bloodstream.

7. d
8. b

UNIT I - NUTRITION

Name________________

Lesson 3: Energy's Role in Livestock Nutrition

Date________________

EVALUATION

Complete the following short answer questions.

1. What are the basic functions of energy in the body?

   a.

   b.

2. What are the two major sources of energy in the livestock ration?

   a.

   b.

3. What are the three elements that make up the molecules of fats and carbohydrates?

   a.

   b.

   c.

4. What are the two major groups of carbohydrates?

   a.

   b.

5. List three reasons to add fat to a ration.

   a.

   b.

   c.

   d.

6. Explain the main difference between how carbohydrates and fats are absorbed and circulated through the body.

Circle the letter that corresponds to the best answer.

7. Which is a possible toxic effect of carbohydrates and fats?

   a. Slower growth in the young
   b. Decrease in milk yield in lactating females
   c. Shortened lactation period
   d. Lower conception rates

8. Which source of energy contains 85 percent of the energy of shelled corn?

   a. Animal fat
   b. Oats
   c. Grain sorghum
   d. Wheat

UNIT I - NUTRITION

Lesson 4: Protein's Role in Animal Nutrition

Objective: The student will be able to describe the function of protein in animal nutrition.

Study Questions

1. **What are the functions of protein?**
2. **What are amino acids and their role in protein synthesis?**
3. **What are the essential amino acids?**
4. **What are the major symptoms of protein deficiency?**
5. **What are sources of protein?**
6. **What determines which proteins should be used in livestock diets?**

References

1. Student Reference
2. Transparency Masters
    - a) TM 4.1: Protein Utilization in the Ruminant
    - b) TM 4.2: Barrel Stave Illustration of the Effect of Limiting Amino Acid Supplementation on Milk Production

Lesson 4: Protein's Role in Animal Nutrition

TEACHING PROCEDURES

A. Review

Review previous lesson on the importance of the nutrient energy in livestock.

B. Motivation

1. What are the signs of protein deficiency in humans? Lack of energy, loss of weight, and tiredness are all signs of protein deficiency in humans. Kwashiorkor is a childhood disease caused by protein deficiency. Symptoms are stunted growth, discolored skin, body sores, and a bulging abdomen. Good protein sources for humans are poultry, fish, dairy products, and dried peas and beans.

2. What are the signs of too much protein in the human diet? Proteins that are not used by the body are converted into body fat, which causes excess amounts of body fat.

C. Assignment

D. Supervised study

E. Discussion

1. See if students know how proteins are used in the body and the purposes they serve.

What are the functions of protein?

a) Functions of proteins in all classes of livestock
    1) Build, repair, and maintain muscles, skin, body tissues, hair, and hooves
    2) Produce body regulators, including enzymes and some hormones
    3) Good source of blood glucose
    4) Provide energy when fed in amounts higher than the body requires
    5) Building blocks in some genetic compounds, including DNA, RNA, and ATP
    6) Used as precursors of some B-complex vitamins

b) Signs of protein deficiencies in livestock
    1) Animal appears thin and has a rough hair coat.
    2) Animals have poor appetites, low digestive efficiencies, and lower production rates.
    3) Animal may die if these deficiencies aren't corrected.

2. Ask students about how amino acids are formed.

What are amino acids and their role in protein synthesis?

a) Definition/functions
    1) Nitrogen compounds that originate from proteins provided in the diet
    2) The bricks and mortar of which muscles, body tissues, skin, and hair are built

b) Amino acids groups
   1) Amino acids are separated into two groups: essential and nonessential amino acids.
   2) There are 23 amino acids; 10 are essential and 13 are nonessential.
   3) All classes of livestock require both groups of amino acids.
c) The role of the amino acids in protein synthesis
   1) Ruminants can synthesize their own amino acids if there is enough nitrogen in the diet.
   2) Non-ruminants must be supplied with essential amino acids in their diet because they cannot synthesize amino acids.
   3) DNA serves as the information center that links amino acids together to form a specific protein with a particular physiological function.

3. Ask students about differences between essential amino acids and non-essential amino acids. Relate the memory aid, "Pvt. Tim Hall," to help students remember amino acids.

What are the essential amino acids?

a) Phenylalanine
b) Valine
c) Threonine
d) Tryptophan
e) Isoleucine
f) Methionine
g) Histidine
h) Arginine
i) Lysine
j) Leucine

4. Ask students if they can tell when an animal is lacking protein in the diet.

What are the major symptoms of protein deficiency?

a) Why symptoms occur in protein synthesis
   1) For a protein to be synthesized, all of the amino acids must be present and available.
   2) If an amino acid is deficient, the protein cannot be made; it must be supplied for the animal.
      EXAMPLE: Corn is deficient in lysine, so lysine must be supplied through another source.
b) Symptoms of amino acid deficiencies
   1) Lack of animal growth
   2) Poor hair coat
   3) Lack of muscling
   4) Lack of energy

5. Discuss the importance of knowing crude protein percentages for feedstuffs.

What are sources of protein?

NOTE: Crude protein is abbreviated CP. The following are book values. Home-raised protein sources should be tested for accurate CP values.

a) Animal protein sources
   1) Feather meal, 87 percent CP
   2) Blood meal, 86 percent CP
   3) Fish meal, 60 percent CP
   4) Poultry byproduct meal, 55 percent CP
   5) Meat scrap, 55 percent CP
   6) Meat and bone meal, 61 percent CP
   7) Dried skim milk, 34 percent CP
   8) Dried whole milk, 25 percent CP

b) Plant protein sources
   1) Sunflower meal, 47 percent CP
   2) Soybean meal, 48 percent CP
   3) Cottonseed meal, 41 percent CP
   4) Rapeseed meal, 37 percent CP
   5) Dehydrated alfalfa meal, 18 percent CP
   6) Alfalfa hay, 15 percent CP
   7) Red clover hay, 13 percent CP
   8) Wheat grain, 12 percent CP
   9) Oat grain, 12 percent CP
   10) Corn grain, 8 percent CP

c) Synthetic sources (N = nitrogen)
   1) Urea is 45 percent N. (Feed only to ruminant animals with a high energy ration.)
   2) Urea is a good source of nitrogen for amino acids.
   3) If the full amount of urea is not used in the rumen, urea toxicity could occur when the byproduct ammonia is produced.

6. Discuss the types of proteins available for feedstuffs. (Use Transparency Masters 4.1 and 4.2.) Using a wooden barrel as an example, describe how the first limiting amino acid influences production. For example, using a barrel with staves cut at different heights, that barrel will hold fluid only to the height of the shortest stave. Similarly, cows will produce milk only to the level of the most limiting nutrient. By providing supplemental rumen-pass protein, we can increase the amount of that limiting amino acid (height of the short barrel stave), thereby increasing milk production.

What determines which proteins should be used in livestock diets?

a) The first step in deciding which proteins to feed **ruminants** is to determine which proteins will be used to feed the microorganisms or "bugs" in the rumen. These microbes can synthesize amino acids from nonprotein nitrogen that nonruminants cannot.
   1) A producer can choose true proteins, such as soybean meal or cottonseed meal. The other option is to feed a nonprotein nitrogen (NPN) feedstuff, such as urea or anhydrous ammonia. These two types of proteins supply nitrogen used by the microbes for protein synthesis.
   2) When using true proteins such as plant protein or animal protein, crude protein does not determine digestibility (amount of protein available to the animal). Crude protein is the total amount of protein available in the feedstuff, but an animal cannot digest all the protein available.
   3) Digestible protein best describes the amount of protein used by the animal.
   4) Price, of course, is another influencing factor.

b) The next consideration is the amount of protein digested by the rumen. Most nonprotein nitrogen feedstuffs are digested and utilized by microbes in the rumen.
   1) In TM 4.1, nonprotein feedstuffs are considered rapidly degraded proteins. Excess amounts of nonprotein nitrogen can result in higher levels of ammonia

in the rumen. Excess rumen ammonia is absorbed into the bloodstream and converted to urea in the liver. The nonprotein nitrogen (rapidly degraded protein) is converted into NH_3 (ammonia), and the excess enters the bloodstream, is transformed into urea in the liver, and leaves the body through the urine. Excess nonprotein nitrogen can result in ammonia toxicity due to high levels of blood ammonia. Only limited amounts of NPN can be used. (Four pounds of urea per cow per day is a safe maximum.)

2) In TM 4.1, bound proteins are the undigestible portions of true proteins. These proteins cannot be digested by the rumen or the small intestine. These proteins are the difference between crude protein and digestible protein. Bound proteins enter and leave the body virtually undigested.

3) There are also true proteins that are considered rapidly degraded proteins. A large part of these proteins are used by microbes in the rumen.

4) The last form of protein is slowly degraded protein. Part of these true proteins are digested in the rumen. Microbes in the rumen use some of them, and the remaining portions escape into the small intestine, where it is digested along with microbial protein and then used for muscle formation and milk production.

c) The last step in classifying feedstuffs is based on rumen digestion.

1) Solubility - Soluble proteins disappear or are digested in two hours or less after entering the rumen. These proteins are classified as "rapidly degraded protein" in TM 4.1. Example sources are urea, alfalfa silage, and anhydrous ammonia. Most of these proteins are used by microbial cells ("bugs").

2) Degradability - Degradable proteins are broken down at a measurable rate over time. The amount of protein digested in the rumen depends on the rate and amount of time spent in the rumen.

(a) These proteins are classified as "rapidly and slowly degraded proteins" in TM 4.1. These proteins are used by microbial cells and the small intestine.

(b) Examples are soybean meal and cottonseed meal.

3) Escape or bypass - These proteins bypass or escape rumen digestion. Most of them are digested and absorbed in the small intestine. These proteins are classified as "slowly degraded proteins" in TM 4.1. Examples are fish meal, blood meal, meat and bone meal, and corn gluten meal.

4) Nonprotein feedstuffs cannot supply all the protein necessary in the diet, but true proteins can. Nonprotein feedstuffs must be supplemented with true proteins.

5) TM 4.2 shows the effects of amino acids on milk production. Milk production in dairy cattle is limited by the lowest limiting amino acid (here, lysine).

(a) In TM 4.2, this animal would only produce 75 lbs. of milk daily because the lysine becomes limiting at this level of milk production.

(b) TM 4.2 also shows what would happen if the diet was supplemented with a bypass protein high in lysine. When this occurs, lysine is no longer the limiting amino acid; methionine now becomes the limiting amino acid.

(c) This change results in increased milk production (75 lbs. to 92 lbs. daily). Paying close attention to ration balancing can mean a much more profitable operation.

(d) This concept of limiting amino acids also applies to nonruminants.

d) Protein digestibility is easier to understand in **nonruminants** because there are no microbial cells to feed and no predigestion before entering the stomach.

1) Table 4.1 in the Student Reference shows the requirements for a growing 100 lb. market hog, as well as the crude protein, digestible protein, and amount of amino acids present in different feedstuffs.

2) A 100 lb. market hog requires a 16 percent crude protein diet. The average 100 lb. hog consumes 4.1 lbs. of feed daily. Of that, 16 percent needs to be crude protein, which is .66 lb. of crude protein. (Remember, this is an estimate.)

e) To further understand the hog's requirement, look at the bottom line of Table 4.1. It shows that the amino acid requirement for the 100 lb. hog is .019 lb. of isoleucine, .025 lb. of leucine, .031 lb. of lysine, .017 lb. of methionine and cystine, .02 lb. of threonine, and .005 lb. of tryptophan.

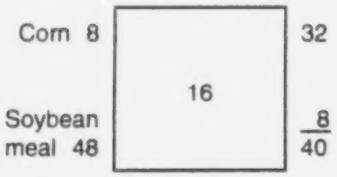
  1) Use blood meal as an example. It has a crude protein percentage of 86 percent, of which 70 percent can be digested.

     EXAMPLE: Of 100 lbs. of blood meal, 86 lbs. are crude protein, while 70 lbs. are usable (digestible) protein. Of the 100 lbs. of blood meal, the total amount of isoleucine is 1.13 lbs. There is .75 lb. of usable (digestible) isoleucine available in 100 lbs. of blood meal. To find out the digestible amount of isoleucine available in 50 lbs. of blood meal, multiply 50 lbs. of blood meal by .0075 digestible isoleucine. (50 x .0075 = .375 lb. of digestible isoleucine)

  2) To find the available digestible leucine in 50 lbs. of blood meal, multiply 50 lbs. of blood meal by .0924. (50 x .0924 = 4.62 lbs.)

  3) Let's use this information in a real life ration. On the average, a 100 lb. hog eats 4.1 lbs. a day. To find out if the ration below meets the amino acid requirements of this hog, find out the total amount of each feedstuff. In the following ration, 3.28 lbs. of the 4.1 lbs. eaten is corn, and .82 lb. is soybean meal. Usually, lysine is the limiting amino acid in most hog rations. Soybean meal will supply .021 lb. of lysine (.82 lb. x .0255 = .021). The corn supplies .006 lb. of lysine (3.28 x .0018 = .006). The hog requires .031 lb. of lysine; these feedstuffs supply .027 lb. of lysine (.021 + .006). This ration, therefore, is lacking lysine. Remember that all hog rations need vitamins and minerals, which have not been figured in yet. In real life, this ration would be balanced for lysine (not protein) to prevent this deficiency form occurring.

     EXAMPLE: Balancing a ration



80% x 4.1 = 3.28 lbs. of corn

20% x 4.1 = .82 lb. of soybean meal

  4) Remember that the 4.1 lbs. eaten daily is an average. In the winter, hogs will eat more than in the summer. To the average producer, using the above ration in the winter wastes money because it includes more amino acids than the hog needs. In the summer, the hog's appetite decreases and its needs are not met because it eats less than 4.1 lbs. a day. Figure 4.1 in the Student Reference shows this difference in eating habits.

  5) If using the above ration, packers receive leaner hogs in the winter because hogs are eating more, so their amino acid needs are met, resulting in more muscle. In the summer, when hogs eat less, their amino acid needs are not met and fat is produced instead of muscle.

f) The processing of feedstuffs improves protein digestibility.

  1) Compare raw soybeans to heated soybeans on Table 4.1 in the Student Reference. Crude protein remains about the same, but the digestibility of heated soybeans jumps up seven percent.

  2) This concept also applies to digestibility of amino acids.

F. Other activities

1. "Litmus Milk Test," *Digestive System of Domesticated Animals (#8833-C).* Agriscience 332H: Advanced Animal Science. College Station, TX: Instructional Materials Service, Texas A & M University, 1990.
2. Compare feather meal (87% CP) and milk. Discus amino acid balances of the two.
3. Students can finish figuring the rest of the amino acids for the example ration to see if the ration is balanced. Or, they can make up a new ration with a new concentrate to see how closely the new ration meets the 100 lb. hog's amino acid requirements.

G. Conclusion

Understanding protein's role in nutrition is economically important because protein is one of the more expensive components in ration development.

H. Competency

Describe protein's role in nutrition.

I. Answers to Evaluation

1. a
2. c
3. b
4. b
5. a, b, c, e, g, h, i (question worth 10 points)
6. c, d, e, h (question worth eight points)
7. a, d, e, f, h (question worth eight points)

UNIT I - NUTRITION

Name____________________

Lesson 4: Protein's Role in Animal Nutrition

Date____________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which is true regarding amino acids?

   a. There are 10 essential and 13 nonessential amino acids.
   b. Amino acids are carbon compounds that originate from plant proteins.
   c. Non-ruminant animals can synthesize their own amino acids.
   d. Ruminants do not synthesize their own amino acids.

2. Which is *false* regarding proteins?

   a. Proteins are used in genetic compounds, such as DNA.
   b. Proteins are essential for body regulators, including enzymes and hormones.
   c. Urea can be fed to non-ruminant animals.
   d. When too much protein is used in the diet, the excess becomes fat.

3. Of the following plant proteins, which has the highest CP value?

   a. Cottonseed meal
   b. Sunflower meal
   c. Alfalfa hay
   d. Oat grain

4. Which is the information center that links amino acids together to form a specific protein the animal can use?

   a. Brain
   b. DNA
   c. RNA
   d. Stomach

Complete the following multiple answer questions.

5. Which are considered essential amino acids? (Check all that apply.)

   ____ a. Arginine
   ____ b. Threonine
   ____ c. Lysine
   ____ d. Lousine
   ____ e. Valine
   ____ f. Valeucine
   ____ g. Histidine
   ____ h. Phenylalanine
   ____ i. Isoleucine
   ____ j. Isocine

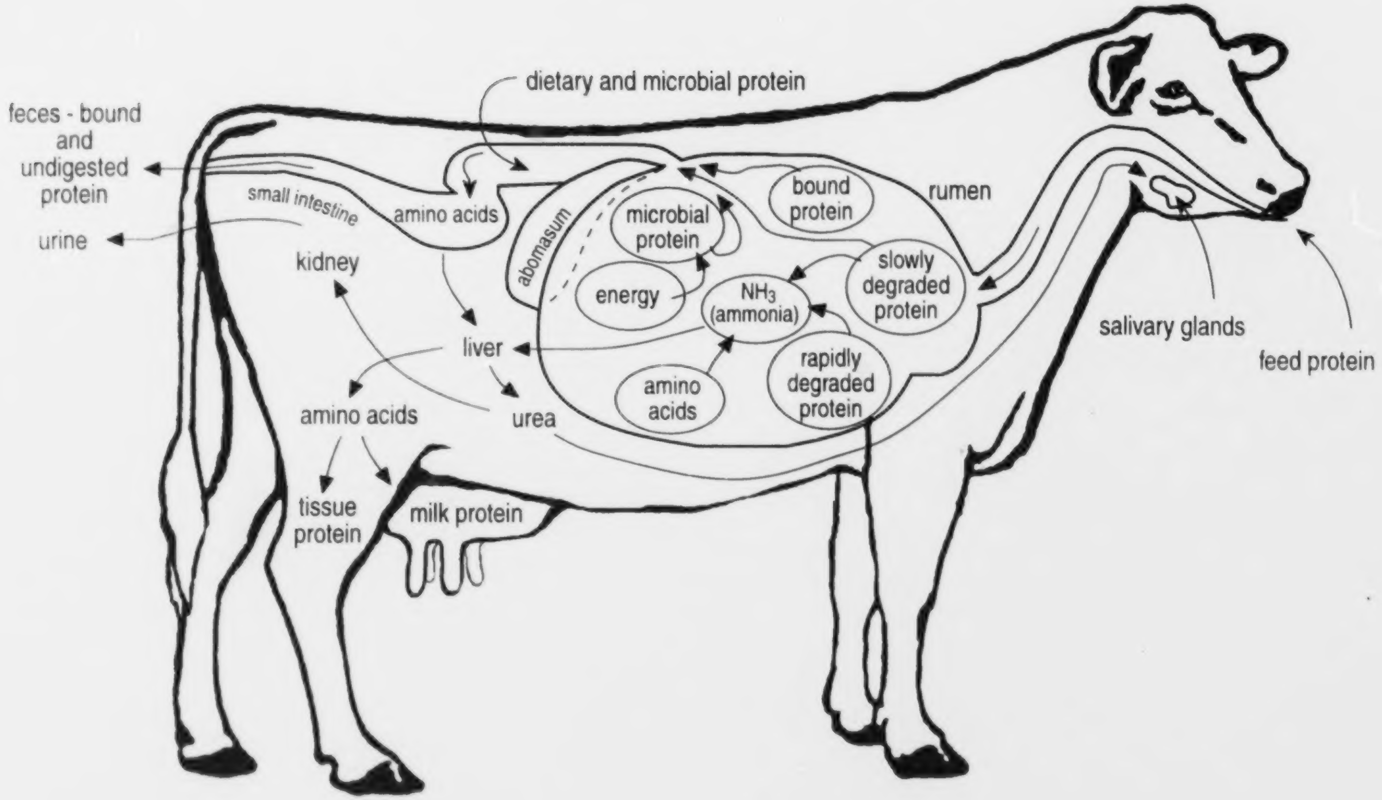
6. Mark with a check the symptoms of protein deficiency.

a. ___ Increased eye watering
b. ___ Hearing loss
c. ___ Poor hair coat
d. ___ Lack of energy
e. ___ Poor growth
f. ___ Poor appetite
g. ___ Diarrhea
h. ___ Lack of muscling

7. What factors need to be considered when determining amount of protein to be fed in a ruminant's diet?

a. ___ Amount of nonproteins fed
b. ___ Mineral content of protein
c. ___ Vitamin content of protein
d. ___ Amount of true proteins fed
e. ___ The limiting amino acid
f. ___ Protein digestibility
g. ___ Energy level in the protein
h. ___ Price of the protein

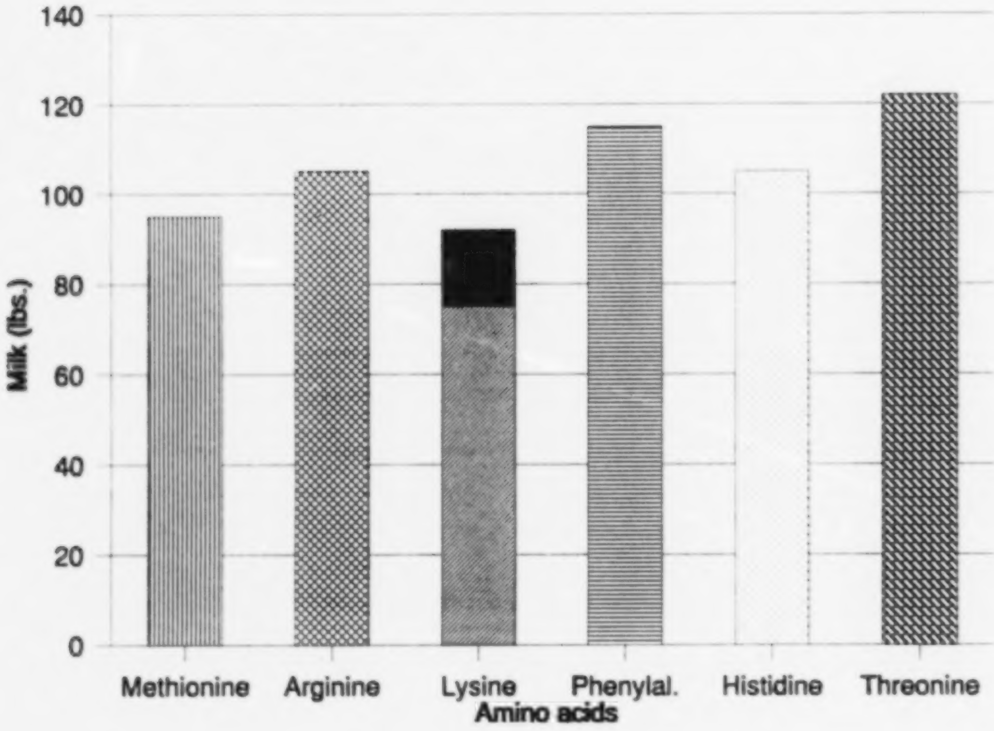
Protein Utilization in the Ruminant


dietary and microbial protein
feces - bound and undigested protein
small intestine
amino acids
urine
kidney
abomasum
microbial protein
bound protein
rumen
energy
NH_3 (ammonia)
slowly degraded protein
salivary glands
feed protein
liver
amino acids
rapidly degraded protein
urea
amino acids
tissue protein
milk protein

65

TM 4.1

Barrel Stave Illustration of the Effect of Limiting Amino Acid Supplementation on Milk Production



Darkest section shows effects of supplemental rumen-bypass lysine.

Credit: Jim Spain, Dairy Science Extension, University of Missouri-Columbia, 1994

UNIT I - NUTRITION

Lesson 5: Minerals' Role in Animal Nutrition

Objective: The student will be able to describe the function of minerals in animal nutrition.

Study Questions

1. **What basic minerals are required for proper animal nutrition?**
2. **What are the functions, deficiency and toxicity symptoms, and sources of macrominerals?**
3. **What are the functions, deficiency and toxicity symptoms, and sources of microminerals?**

References

1. Student Reference

UNIT I - NUTRITION

Lesson 5: Minerals' Role in Animal Nutrition

TEACHING PROCEDURES

A. Review

Review the previous lesson on the role of protein in nutrition.

B. Motivation

1. What are some symptoms of mineral deficiencies in humans? What are the roles that minerals play in human nutrition? Deficiencies in calcium and phosphorus cause improper bone growth. Osteoporosis is caused by a lack of calcium. Deficiencies in magnesium cause major kidney malfunctioning and severe diarrhea. Shortages of sodium, chlorine, and potassium are rare, but in cases of severe diarrhea, burns, and vomiting, these minerals need to be replaced.

2. What happens if minerals are taken in excessive amounts by humans? In most cases, the human body will get rid of any excess amounts of minerals. Except for sodium, it is very difficult to consume too many minerals. (Sodium is connected to high blood pressure and fluid retention in the body.)

C. Assignment

D. Supervised study

E. Discussion

1. Ask students to discuss the minerals they know that are recommended for animals.

What basic minerals are required for proper animal nutrition?

a) Minerals are a group of inorganic elements needed by livestock for production and maintenance.
    1) Because they are inorganic, minerals cannot be synthesized by animals or microorganisms.
    2) If a particular mineral is needed, it must be provided in the diet in a form that can be digested, absorbed, and used in metabolism.
    3) Rations must be formulated so that a mineral imbalance does not occur.

b) Dissolved minerals are absorbed into the bloodstream through villi in the small intestine. Leftover minerals are absorbed directly into the bloodstream through capillaries in the wall of the large intestine.

c) Minerals are classified according to the dietary concentration needed to fulfill the animal's requirements.
    1) Macro- and micro-minerals are both important, but macro-minerals are needed in larger amounts. Macro-minerals are:
        (1) Calcium (Ca)
        (2) Salt--sodium chloride (NaCl)
        (3) Phosphorus (P)
        (4) Magnesium (Mg)
        (5) Potassium (K)

2) Trace or micro-minerals
    (1) Sulfur (S)
    (2) Chromium (Cr)
    (3) Cobalt (Co)
    (4) Copper (Cu)
    (5) Fluorine (F)
    (6) Iodine (I)
    (7) Iron (Fe)
    (8) Manganese (Mn)
    (9) Molybdenum (Mo)
    (10) Selenium (Se)
    (11) Silicon (Si)
    (12) Zinc (Zn)

d) General functions of minerals
    1) Filling in soft bone and teeth cells to make a cell that is hard and rigid
    2) Cell structure and integrity
    3) Part of organic compounds such as proteins, amino acids, carbohydrates, and fats
    4) Control the location of body water through osmotic pressure
    5) Provide an acid-base balance, which regulates the pH of body fluids at about 7.0
    6) Coenzymes that activate enzymes
    7) Necessary components of hormones
    8) Essential part of blood, body fluids, and some secretions in the body
    9) Egg production

e) Some minerals, such as arsenic, cadmium, mercury, and lead, are toxic to animals.

2. Discuss the functions of the required macro-minerals and what happens when enough minerals are not consumed.

What are the functions, deficiency and toxicity symptoms, and sources of macro-minerals?

a) Calcium (Ca)
    1) Major functions
        (1) Bone and teeth formation and maintenance
        (2) Approximately 99 percent of the body's calcium present in bones and teeth
        (3) Nerve function
        (4) Muscle contraction
        (5) Blood coagulation
        (6) Essential for milk production and for forming eggshells in poultry
    2) Deficiency symptoms
        (1) Rickets in youth
        (2) Osteoporosis in adults
        (3) Milk fever in dairy cows
        (4) Thin-shelled eggs, drop in egg production, and lowered hatchability in poultry
    3) Major interrelationships/toxicities
        (1) The calcium-to-phosphorus ratio is important.
        (2) Vitamin D is critical because a deficiency of vitamin D in the ration prevents the proper utilization of calcium.
        (3) Excess Ca reduces the absorption and utilization of Zn.
        (4) Excess Mg decreases Ca absorption, replaces Ca in the bones, and increases Ca excretion.

4) Good sources for animals
   (1) Oyster shells
   (2) Limestone
   (3) Protein supplements of animal origin
   (4) Legume forages, such as alfalfa or clover hay
   (5) Milk
   (6) Bonemeal

   NOTE: Only 20-30 percent of Ca in the average ration is absorbed from the intestinal tract and taken into the bloodstream.

b) Salt (sodium chloride, NaCl)
   1) Major functions
      (1) Salt helps maintain osmotic pressure in body cells, upon which depends the transfer of nutrients to the cells and the removal of waste materials.
      (2) Sodium (Na) is associated with muscle contraction and is important in making bile, which aids in the digestion of fats and carbohydrates.
      (3) Chlorine (Cl) is required for the formation of hydrochloric acid in the gastric juice, which is vital to protein digestion.
   2) Deficiency symptoms
      (1) Reduced growth and efficiency of feed utilization in growing animals
      (2) Reduced milk production and weight loss in adults
      (3) Lowered reproduction (infertility in males and delayed sexual maturity in females)
      (4) Craving for sodium, evidenced by behavior such as drinking urine or licking the ground
      (5) In laying hens, lowered production, loss of weight, and cannibalism
   3) Major interrelationships/toxicities
      (1) Salt toxicity, which is accentuated by low water intake, readily occurs in nonruminants. It is characterized by a staggering gait, blindness, and other nervous disorders.
      (2) Salt toxicity rarely occurs in ruminants.
      (3) Salt-starved ruminants can overeat if given unlimited access to salt, causing digestive disturbances or death.
   4) Good sources for animals
      (1) Salt given free choice
      (2) Salt added to the ration at a level of 0.25-0.50 percent

c) Phosphorus (P)
   1) Major functions
      (1) Bone and teeth formation and maintenance
      (2) Component of phospholipids, which are important in lipid transport and metabolism, as well as cell-membrane structure
      (3) Milk secretion
      (4) Energy metabolism
      (5) A component of RNA and DNA
      (6) Constituent of several enzyme systems
      (7) Affects conversion of carotene into vitamin A
      (8) Utilization of vitamin D
   2) Deficiency symptoms
      (1) Rickets in young
      (2) Osteoporosis in adults
      (3) Poor appetite
      (4) Breeding problems
      (5) Reduced egg production in hens
      (6) Poor utilization of vitamins A and D

- 3) Major interrelationships/toxicities
  - (1) The Ca-P ratio is important.
  - (2) Sufficient Vitamin D is necessary for P assimilation and utilization.
  - (3) Excess Ca and Mg cause a decrease in P absorption.
  - (4) P is more efficiently absorbed than calcium; about 70 percent of ingested phosphorus is absorbed.
  - (5) Excess P may result in lameness and spontaneous fracture of long bones.
  - (6) High P has a laxative effect.
- 4) Good sources for animals
  - (1) Adequate level of vitamin D
  - (2) Most cereal grains and their by-products (notably wheat bran)

d) Magnesium (Mg)

- 1) Major functions
  - (1) Essential for normal skeletal development
  - (2) Constituent of bones and teeth
  - (3) Enzyme activator
  - (4) Involved in activating certain enzyme systems and in protein digestion
  - (5) Relaxes nerve impulses
  - (6) Serves as a ruminant alkalizer and buffer
- 2) Deficiency symptoms
  - (1) Vasodilation, with resulting reduction in blood pressure (shown by the flushing of the skin)
  - (2) Hyperirritability
  - (3) Grass tetany, characterized by loss of appetite, convulsions, staggering, and death
  - (4) Decreased utilization of phosphorus
- 3) Major interrelationships/toxicities
  - (1) Excess Mg upsets calcium and phosphorus metabolism.
  - (2) Added Mg can cause a zinc deficiency.
- 4) Good sources for animals
  - (1) Magnesium sulfate or oxide
  - (2) Mixed with feed or in a commercial mineral

e) Potassium (K)

- 1) Major functions
  - (1) Major cation (positively charged ion) in intracellular fluid, where it is involved in osmotic pressure and acid-base balance
  - (2) Relaxes the heart muscle
  - (3) Involved in secretion of insulin
  - (4) Involved in carbohydrate metabolism and protein synthesis
- 2) Deficiency symptoms
  - (1) Reduced growth
  - (2) Unsteady gait
  - (3) General muscle weakness
  - (4) Diarrhea
  - (5) Enlargement of the heart and kidneys, followed by death
  - (6) May occur in dry lot finishing cattle or sheep on a high-concentrate ration
- 3) Major interrelationships/toxicities
  - (1) Excessive levels of potassium interfere with magnesium absorption.
  - (2) The resulting magnesium deficiency results in failure to retain potassium, leading to potassium deficiency.
  - (3) Excessive salt intake depletes the body's potassium.
- 4) Good sources for animals--generally adequate in most animal rations

3. Ask the students about the functions of micro-minerals. What happens when too little (or too much) is fed?

What are the functions, deficiency and toxicity symptoms, and sources of micro-minerals?

a) Sulfur (S)
    1) Major functions
        (1) Sulfur is required as a component of sulfur-containing amino acids cystine and methionine.
        (2) A component of biotin, sulfur is important in lipid metabolism.
        (3) As a component of coenzyme A, sulfur is important in energy metabolism.
        (4) Sulfur is a component of hair, wool, and feathers.
    2) Deficiency symptoms
        (1) There is reduced and slowed growth, primarily due to not meeting the sulfur amino acid requirement for protein synthesis.
        (2) Sheep that are fed nonprotein nitrogen without sulfur supplements show reduced wool growth. (Wool contains about 4 percent sulfur.)
    3) Major interrelationships/toxicities--none
    4) Good sources for animals
        (1) Forages, especially legumes which are harvested in the earlier growth stages, should contain enough sulphur for ruminants.
        (2) Nonruminants should be provided sulfur-containing proteins.
b) Chromium (Cr)
    1) Major functions
        (1) Glucose metabolism
        (2) Activator of certain enzymes
        (3) Stabilizer of nucleic acids
        (4) Stimulation of the synthesis of fatty acids and cholesterol in the liver
    2) Deficiency symptoms
        (1) Impaired glucose tolerance
        (2) Disturbance of lipid and protein metabolism
    3) Supplements not generally needed
c) Cobalt (Co)
    1) Major functions
        (1) Essential for vitamin B_{12} synthesis
        (2) Used by rumen microorganisms in the growth of rumen bacteria
    2) Deficiency symptoms
        (1) Symptoms similar vitamin B_{12} deficiency are shown in cattle and sheep.
        (2) Ruminants grazing in cobalt-deficient areas show loss of appetite, reduced growth, and loss in body weight, followed by emaciation, anemia, and eventually death.
    3) Major interrelationships/toxicities
        (1) Related to vitamin B_{12}
        (2) Toxicity not likely
    4) Good sources for animals
        (1) Commercial minerals
        (2) Poultry by-product meal, soybean meal, and molasses
d) Copper (Cu)
    1) Major functions
        (1) Along with iron and vitamin B_{12}, necessary for hemoglobin formation
        (2) Essential in enzyme systems
        (3) Essential for hair development and pigmentation
        (4) Essential for lactation and reproduction

- 2) Deficiency symptoms
    - (1) Fading hair coat
    - (2) Severe diarrhea
    - (3) Abnormal wool growth and straight, hairlike fibers
    - (4) Condition known as swayback in newborn lambs
    - (5) Nutritional anemia
- 3) Major interrelationships/toxicities
    - (1) Excess copper is toxic; it accumulates in the liver, and death may result, especially in sheep.
    - (2) Cu is involved in iron metabolism.
- 4) Good sources for animals
    - (1) Trace-mineralized salt containing copper sulfate
    - (2) Commercial minerals
- 5) Additional comments
    - (1) A variable store of copper is located in the liver and spleen.
    - (2) Milk is low in copper; therefore, young animals raised solely on milk may develop anemia.
    - (3) Do not supply sheep with commercial minerals containing copper; it may be lethal because copper accumulates in bodies and does not metabolize.

e) Fluorine (F)

- 1) Major function--necessary for sound bones and teeth
- 2) Deficiency symptoms--uncommon
- 3) Major interrelationships/toxicities
    - (1) Large amounts of calcium, aluminum, or fat will lower the absorption of fluorine.
    - (2) High dietary Ca depresses F uptake in bone
    - (3) Since fluorine is a cumulative poison, toxic effects may not be noticed for some time.
    - (4) High levels result in enlarged bones; softening, mottling, and irregular wear of the teeth; roughened hair coat; delayed maturity and less efficient utilization of feed.
- 4) Good sources for animals--supplements not needed

f) Iodine (I)

- 1) Major functions
    - (1) Iodine is needed by the thyroid gland to make thyroxin.
    - (2) Thyroxin controls the rate of body metabolism or heat production.
- 2) Deficiency/toxicity
    - (1) Goiter (big-neck) in humans, calves, lambs, and goats; stillbirths and weak young; hairless pigs and wool-less lambs at birth
    - (2) No satisfactory treatment for animals that have developed pronounced iodine deficiency symptoms
    - (3) Enlargement of the thyroid gland (goiter) is nature's way of trying to make enough thyroxin when there is insufficient iodine in the diet.
    - (4) Long-term chronic intake of large amounts of iodine reduces the thyroid uptake of iodine.
- 3) Good sources for animals
    - (1) Calcium iodate
    - (2) Iodized salt
    - (3) Whey and molasses

g) Iron (Fe)

- 1) Major functions
    - (1) Constituent of hemoglobin, the iron-containing compound that transports oxygen in the blood
    - (2) Plays a role in cellular oxidation

  2) Deficiency symptom--iron-deficient anemia in nursing pigs in confinement
  3) Major interrelationships/toxicities
    (1) Copper is required for proper Fe metabolism.
    (2) Too much iron interferes with phosphorus absorption.
  4) Good sources for animals
    (1) Iron dextran given orally or by injection to young pigs
    (2) Leafy portions of plants
    (3) Legumes
    (4) Trace-mineralized salt
  5) Additional comments
    (1) Iron is stored in the liver, spleen, and kidneys.
    (2) Young animals are born with a store of iron, but milk is low in iron. Therefore, if young animals continue on milk for a long time, particularly under confined conditions, anemia will likely develop.

h) Manganese (Mn)
  1) Major functions
    (1) Essential for normal bone formation and growth of other connective tissues
    (2) Blood clotting
    (3) Synthesis of fatty acids
  2) Deficiency symptoms
    (1) Poor growth
    (2) Lameness, shortening, and bowing of the legs, and enlarged joints
    (3) Swollen and stiff joints
    (4) Impaired reproduction
    (5) Slipped tendons in poultry
    (6) Pinkeye
  3) Major interrelationships/toxicities
    (1) Excess Ca and P decrease absorption.
    (2) Mn is not toxic in moderate excesses.
  4) Good sources for animals
    (1) Trace-mineralized salt
    (2) Rice, wheat, and hay

i) Molybdenum (Mo)
  1) Major functions
    (1) Component of three different enzyme systems involved in the metabolism of carbohydrates, fats, proteins, and iron
    (2) Stimulates action of rumen organisms
  2) Deficiency symptoms--none
  3) Major interrelationships/toxicities
    (1) Utilization is reduced by excess copper sulfate and tungsten.
    (2) Molybdenum is related to uric acid formation in poultry and microbial action in ruminants.
    (3) Toxic levels of Mo interfere with copper metabolism.
    (4) Mo toxicity results in severe scours and loss of condition.
  4) Good sources for animals--no supplementing of normal rations necessary

j) Selenium (Si)
  1) Major functions
    (1) Protects tissue against certain poisonous substances, such as arsenic, cadmium, and mercury
    (2) Involved in vitamin E absorption and retention
    (3) Prevents degeneration and fibrosis of the pancreas in chicks

- 2) Deficiency symptoms
  - (1) Nutritional muscular dystrophy (called white muscle disease in calves) or stiff lamb disease in sheep
  - (2) Liver damage in swine
- 3) Major interrelationships/toxicities
  - (1) Excess selenium consumption results in blind staggers, lameness, anemia, excess salivation, grinding of the teeth, and blindness.
  - (2) Excess in poultry results in reduced egg production and deformities such as lack of eyes and deformed wings and feet.
- 4) Good sources for animals
  - (1) Marine by-products, such as seaweed and kelp
  - (2) Cereal grains and wheat by-products

k) Silicon (Si)
- 1) Major function--necessary for normal growth and skeletal development of chicks
- 2) Deficiency symptoms
  - (1) Slow growth
  - (2) Skeletal deformities, especially in the skull
- 3) Good sources for animals--present in large amounts in soil and plants
- 4) Additional comments--On purified diets, the addition of silicon has increased the growth rate of chicks.

l) Zinc (Zn)
- 1) Major functions
  - (1) Needed in normal skin, bones, hair, and wool
  - (2) Component of several enzyme systems
  - (3) Gives bloom to the hair coat
- 2) Deficiency symptoms
  - (1) Loss of appetite
  - (2) Stunted growth
  - (3) Poor hair or feather development
  - (4) Rough and thickened skin in swine (parakeratosis)
- 3) Major interrelationships/toxicities
  - (1) Excess calcium reduces the absorption and utilization of zinc.
  - (2) Excess zinc interferes with copper metabolism and may cause anemia.
- 4) Good sources for animals
  - (1) Fish meal
  - (2) Corn gluten feed and meal
  - (3) Poultry by-products
  - (4) Added to trace-mineralized salt

F. Other activities

1. Have students bring in tags from various commercial mineral mixes and compare the amounts and types of minerals that are present.

2. Invite a nutrition specialist or feed representative talk about the importance of minerals in an overall nutrition plan.

3. Obtain videos to show abnormalities in animals. Contact Creative Educational Videos, PO Box 65265, Lubbock, TX 79424 (800/922-9965) for:

   a) Cattle Abnormalities (26 min., #2010108WIS15002Q)
   b) Sheep Abnormalities (24 min., #2010108WIS15000Q)
   c) Swine Abnormalities (26 min., #2010108WIS15001Q)

G. Conclusion

At least 18 mineral elements are needed by animals. Those needed in large amounts are referred to as major or macro-minerals, while those needed in small amounts are called trace or micro-minerals. Minerals are required for the development of bones and teeth, as well as for many other functions in the body. Deficiencies cause lower production and poor gains, but rarely cause diseases or death. Commercial feeds and mineral mixes are the most common sources of minerals in livestock rations. Minerals can be mixed in complete feeds or fed free choice.

H. Competency

Describe minerals' role in nutrition.

I. Answers to Evaluation

1. a
2. h
3. g
4. f
5. d
6. i
7. e
8. b
9. j
10. i
11. a
12. g
13. d
14. f
15. h

16. Any four of the following:
    a. Filling in soft bone and teeth cells to make a cell that is hard and rigid
    b. Cell structure and integrity
    c. Part of organic compounds such as proteins, amino acids, carbohydrates, and fats
    d. Control the location of body water via osmotic pressure
    e. Provide an acid-base balance, which regulates the pH of body fluids at about 7.0
    f. Coenzymes that activate enzymes
    g. Necessary components of hormones
    h. Essential part of blood, body fluids, and some secretions in the body
    i. Egg production

17. Sodium = Na
    Potassium = K
    Magnesium = Mg
    Copper = Cu
    Iron = Fe

18. Small intestine and large intestine

UNIT I - NUTRITION

Name__________________

Lesson 5: Minerals' Role in Animal Nutrition

Date__________________

EVALUATION

Match the following minerals on the right with their corresponding functions on the left.

___ 1. Bone and teeth formation; nerve function; muscle contraction and blood coagulation.

___ 2. Helps maintain osmotic pressure in body cells; required for muscle contraction; required for making bile and hydrochloric acid

___ 3. Relaxes the heart muscle and is involved in the secretion of insulin

___ 4. Component of RNA and DNA

___ 5. Needed by the thyroid gland to produce thyroxin

___ 6. Needed for normal skin, bones, hair, and feathers

___ 7. Constituent of hemoglobin; plays a role in cellular oxidation

a. Calcium
b. Copper
c. Fluorine
d. Iodine
e. Iron
f. Phosphorus
g. Potassium
h. Salt
i. Zinc

Match the following minerals on the right with their correct deficiency symptom(s) on the left.

___ 8. Emaciation, anemia, and eventually death in ruminants

___ 9. Rough and thickened skin in swine (parakeratosis)

___ 10. Stunted growth and skeletal deformities in chicks

___ 11. Tetany or milk fever in cows

___ 12. Enlargement of the heart and kidneys

___ 13. Goiter (enlargement of the thyroid gland)

___ 14. Lameness, swelling of the joints, and fragility of the bones

___ 15. White muscle disease in calves and stiff lamb disease in sheep

a. Calcium
b. Cobalt
c. Fluorine
d. Iodine
e. Iron
f. Manganese
g. Potassium
h. Selenium
i. Silicon
j. Zinc

Complete the following short answer questions.

16. List four general functions of minerals.

    a.

    b.

    c.

    d.

17. Give abbreviations for the following minerals.

    a. Sodium =

    b. Potassium =

    c. Magnesium =

    d. Copper =

    e. Iron =

18. Where minerals are absorbed?

UNIT I - NUTRITION

Lesson 6: Vitamins' Role in Animal Nutrition

Objective: The student will be able to describe the function of vitamins in livestock nutrition.

Study Questions

1. **What basic vitamins are required?**
2. **What are the functions, deficiency symptoms, and important sources of fat-soluble vitamins?**
3. **What are the functions, deficiency symptoms, and important sources of B complex vitamins?**
4. **What are the functions, deficiency symptoms, and important sources of other water-soluble vitamins?**

References

1. Student Reference

UNIT I - NUTRITION

Lesson 6: Vitamins' Role in Animal Nutrition

TEACHING PROCEDURES

A. Review

Review previous lesson on the role of minerals in animal nutrition.

B. Motivation

1. What are some vitamin deficiencies found in humans? What are the functions of vitamins in human nutrition? Deficiencies of vitamin A cause night blindness, rough skin, stunted growth, and eyes that are light sensitive. Deficiencies of vitamin D cause improper usage of calcium and phosphorus, which can result in rickets. Deficiencies of vitamin E are very rare. Severe vitamin K deficiency causes hemorrhaging. A lack of vitamin C causes loss of appetite, soreness of joints, bleeding gums, bruising, and scurvy. In humans and dogs, a lack of folic acid can result in a sore, red tongue, disturbance of the digestive tract, and poor growth.

2. What happens if vitamins are taken in excessive amounts by humans? Extra amounts of vitamins are discarded by the body, but there are extreme cases for each vitamin. Too much vitamin C may cause diarrhea. Too much vitamin K or E may be toxic. Excessive vitamin D may result in severe damage to kidneys, lungs, and bones. Too much vitamin A may cause fatigue, headaches, vomiting, and nausea.

3. What are some similarities between swine and humans? How are the nutrient requirements the same? Both swine and humans cannot produce B-complex vitamins. These vitamins must be provided in their diet.

C. Assignment

D. Supervised study

E. Discussion

1. Ask the students to discuss why vitamins are important and what vitamins are required for good nutrition.

What basic vitamins are required?

- a) General definition
    - 1) Vitamins are a feedstuff component distinct from carbohydrates, fat, protein, minerals, and water.
    - 2) They are essential for development of tissues and the growth and maintenance of the animal.
- b) Classification by solubility
    - 1) Fat-soluble vitamins
        - (a) Stored in the animal's fat tissue
        - (b) Enable livestock to survive on vitamin-deficient diets for lengths of time without deficiency symptoms.
        - (c) Includes:
            - (1) Vitamin A

(2) Vitamin D
(3) Vitamin E
(4) Vitamin K
2) Water-soluble vitamins
(a) Stored within the animal for only 2-4 days
(b) Must be contained in the diet
(c) Includes:
(1) Inositol
(2) Niacin
(3) Vitamin C
(4) B_1 (thiamine)
(5) B_2 (riboflavin)
(6) B_3 (pantothenic acid)
(7) B_6 (pyridoxine)
(8) B_{12}
(9) Biotin
(10) Choline
(11) Folic acid
(12) Para-aminobenzoic acid (PABA)
c) General sources for all vitamins
1) Protein supplements
2) Mineral premixes
3) Feed tags show the guaranteed minimum and maximum percentages of calcium, minimum percentage of phosphorus, and minimum and maximum percentages of salt in the feed.
4) Vitamins are usually added to mixed rations or provided free choice.
d) Arsenic, cadmium, lead, and mercury are all toxic to livestock. Prevent contamination of feed by these elements.

2. Discuss with students the functions of the various required vitamins that dissolve in fat.

What are the functions, deficiency symptoms, and important sources of fat-soluble vitamins?

a) Vitamin A
1) Major functions
(a) Eyesight maintenance (formation of visual purple in the eye for night vision)
(b) Essential for body growth, bone growth, and normal tooth development
(c) Epithelial tissue maintenance in respiratory, urogenital, and digestive tracts, and the skin
2) Deficiency symptoms
(a) Night blindness and potential blindness
(b) Stunted growth or loss of weight and loss of appetite
(c) Nervous incoordination as shown by a staggering gait
(d) Unsound teeth and rough, dry skin
(e) Sterility in males and females
(f) Wobbly gait in chicks
(g) Reduced egg production and hatchability in hens
3) Good sources for animals
(a) Vitamin A can be provided as a synthetic vitamin or as carotene.
(b) Major sources of carotene are:
(1) Leafy green hays, not over one year old
(2) Grass silage

- (3) Lush green pastures
- (4) Whole milk
- (5) Dehydrated alfalfa meal
- (6) Yellow corn

4) Additional comments
  - (a) Vitamin A itself is only present in animals. Plants contain the precursor, carotene.
  - (b) Animals can store considerable amounts of vitamin A. Young animals suffer from deficiency sooner because of their greater requirements and reduced storage ability.
  - (c) Vitamin A and carotene are readily destroyed by oxidation, thus resulting in considerable losses in processing and storing (such as in making and storing hay).

b) Vitamin D
- 1) Major functions
  - (a) Aids in the assimilation and utilization of calcium and phosphorus
  - (b) Necessary for the normal bone development of animals, including the bone in the fetus
  - (c) Promotes sound teeth
- 2) Deficiency symptoms
  - (a) Rickets in young
  - (b) Osteoporosis in adults
  - (c) Tetany, which is characterized by muscle twitching, convulsions, and low serum calcium
  - (d) Poor eggshells and lowered hatchability in hens
- 3) Good sources for animals
  - (a) Sunlight
  - (b) Sun-cured hays
- 4) Additional comments
  - (a) When animals are exposed to direct sunlight, the ultraviolet light in the sunlight penetrates the skin and produces vitamin D from traces of certain cholesterol in the tissues.
  - (b) Tissue storage is very limited.
  - (c) The vitamin D requirement is less when the proper balance of calcium and phosphorus exists.

c) Vitamin E
- 1) Major functions
  - (a) Antioxidant
  - (b) Essential for the integrity of red blood cells
  - (c) Essential in cellular respiration, primarily in heart and skeletal muscle tissue
  - (d) Regulator in the synthesis of DNA and vitamin C
- 2) Deficiency symptoms
  - (a) Muscular dystrophy (stiff-limb disease in lambs and white muscle disease in calves)
  - (b) Reproductive failure
  - (c) Poor hatchability in hens
- 3) Good sources for animals
  - (a) Rice polishings
  - (b) Wheat germ meal
  - (c) Alfalfa meal
  - (d) Green grass
  - (e) Early cut hay

4) Additional comments
    (a) Vitamin E is widely distributed in all natural feeds.
    (b) Utilization of vitamin E depends on adequate selenium.

d) Vitamin K
    1) Major function--essential for blood clotting
    2) Deficiency symptoms
        (a) Prolonged blood clotting time
        (b) Generalized hemorrhages
        (c) Death, in severe cases
    3) Good sources for animals
        (a) Green pastures
        (b) Well-cured hays
        (c) Fish meal
        (d) Usually widely distributed in normal farm rations
        (e) Synthesized by all classes of farm animals

    NOTE: A well-known enemy of vitamin K is dicoumarol, which is present in moldy sweet clover hay.

3. Discuss with students the functions of the various B vitamins, which are water-soluble. Do they have similarities?

What are the functions, deficiency symptoms, and important sources of B complex vitamins?

a) Biotin
    1) Major functions
        (a) Required in many reactions in the metabolism of carbohydrates, fats, and proteins
        (b) Serves as a coenzyme for transferring CO_2 from one compound to another
        (c) Serves as a coenzyme for the production of energy
    2) Deficiency symptoms
        (a) Pigs exhibit spastic hind legs, cracks in the feet, dermatitis, and lower feed efficiency.
        (b) Hatchability is severely reduced in hens.
    3) Good sources for animals
        (a) Synthetic biotin
        (b) Alfalfa meal
        (c) Black strap molasses
        (d) Green forages
        (e) Soybean meal
    4) Ordinary farm rations probably contain ample biotin, or farm animals synthesize all they need.

b) Choline
    1) Major functions
        (a) Involved in the prevention of fatty livers
        (b) Involved in transmitting nerve impulses
        (c) Involved in the metabolism of fat
    2) Deficiency symptoms
        (a) Poor growth and fatty livers in most species
        (b) Slipped tendons in chickens and turkeys
        (c) In swine, abnormal gait in growing pigs and reproductive failure in adult females
    3) Good sources for animals
        (a) Soybean lecithin

    - (b) Yeast
    - (c) Canola meal
    - (d) Fish meal
  - 4) Additional comments
    - (a) With a high-protein diet, enough choline is synthesized from certain precursors and amino acids.
    - (b) Deficiency symptoms are more visible as the protein content is lowered.
- c) Folic acid
  - 1) Major functions
    - (a) Involved in combining single carbon units into larger molecules
    - (b) Related to vitamin B$_{12}$ metabolism
    - (c) Formation of many essential amino acids
  - 2) Deficiency symptoms
    - (a) In chicks, reduced growth and depigmentation of colored feathers
    - (b) Lower egg production and hatchability
  - 3) Good sources for animals
    - (a) Synthetic folacin
    - (b) Wheat germ
    - (c) Soybean meal
    - (d) Alfalfa hay
    - (e) Cottonseed meal
- d) Vitamin B$_1$ (thiamine)
  - 1) Major functions
    - (a) Coenzyme in energy metabolism
    - (b) Functioning of the peripheral nerves
    - (c) Maintains normal appetite
    - (d) Maintains muscle tone
    - (e) Maintains healthy mental attitude
  - 2) Deficiency symptoms
    - (a) Utilization of thiamin is hindered by high fat diets.
    - (b) Reduced appetite, anorexia, and loss in weight
    - (c) Slower heartbeat and enlargement of the heart
    - (d) Lowered body temperature
    - (e) Lowered egg production in hens
  - 3) Good sources for animals
    - (a) Dietary source of vitamin B$_1$ needed for all animals but ruminants
    - (b) Cereal grains
    - (c) Green, leafy hay
    - (d) Commercial vitamin premixes
- e) Riboflavin (vitamin B$_2$)
  - 1) Major functions
    - (a) Promotes growth and functions in the body as a constituent of several enzyme systems
    - (b) Important in carbohydrate, fatty acid, and amino acid metabolism
  - 2) Deficiency symptoms
    - (a) Stunted growth
    - (b) Periodic moon blindness in horses
    - (c) Reproductive failure in the sow
    - (d) Slow growth, anemia, diarrhea, and abnormal gait in the young pig
    - (e) Curled toe paralysis in birds
  - 3) Good sources for animals
    - (a) Synthetic riboflavin
    - (b) Milk
    - (c) Alfalfa hay

(d) Green pastures
4) Additional comments
(a) Grains are poor sources of riboflavin.
(b) Many common rations, especially swine and poultry rations, are borderline or deficient in riboflavin.
(c) Riboflavin is destroyed by light or heat.

f) Vitamin B_3 (pantothenic acid)
1) Major functions
(a) B_3 is a component of coenzyme A, which is required for energy metabolism.
(b) Coenzyme A is required by the cells in the biosynthesis of fatty acids.
2) Deficiency symptoms
(a) All species exhibit reduced growth, loss of hair, and enteritis.
(b) Signs of deficiency in calves are a rough coat, dermatitis, anorexia, and loss of hair around the eyes. (Mature ruminants synthesize vitamin B_3 in the rumen.)
3) Good sources for animals
(a) Yeast
(b) Whey
(c) Alfalfa meal
4) Additional comments
(a) Grain is very deficient in vitamin B_3.
(b) Of all the B vitamins, B_3 is most likely to be deficient under dry lot conditions.
(c) Vitamin B_3 is commonly added to commercial swine and poultry rations.

g) Vitamin B_6 (pyridoxine)
1) Major functions
(a) Coenzyme in protein and nitrogen metabolism
(b) Involved in red blood cell formation and in absorption of amino acids
(c) Involved in carbohydrate and fat metabolism
2) Deficiency symptoms
(a) All species exhibit convulsions.
(b) Pigs show anorexia and poor growth.
(c) Chicks experience stunted growth and abnormal feathering.
(d) Hens show lowered egg laying and hatchability.
3) Good sources for animals
(a) Green pasture
(b) Wheat
(c) Alfalfa hay
4) Additional comments
(a) B_6 is synthesized in the rumen of cattle and sheep and perhaps in the cecum of the horse.
(b) Normally, animal rations are not lacking in vitamin B_6.

h) Vitamin B_{12}
1) Major functions
(a) B_{12} functions as a coenzyme in a variety of metabolic reactions.
(b) B_{12} is necessary for the maturation of red blood cells.
2) Deficiency symptoms
(a) Generally, there is stunted growth.
(b) Pigs show uncoordinated hind leg movements, and there is reproductive failure in sows.
(c) Eggs from B_{12} deficient hens do not hatch.
3) Good sources for animals
(a) Synthetic B_{12}

            - (b) Protein supplements of animal origin
            - (c) Fermentation products
        - 4) Additional comments
            - (a) Ruminants synthesize B_{12} in the rumen.
            - (b) B_{12} is apt to be lacking in swine and breeder poultry rations.
    - i) Para-aminobenzoic acid (PABA)
        - 1) Major functions
            - (a) Essential part of the folacin molecule
            - (b) Essential growth factor for certain microorganisms
        - 2) Deficiency symptoms are not demonstrated in animals.
        - 3) Good sources for animals
            - (a) Synthetic PABA
            - (b) Lecithin
            - (c) Soybean meal
            - (d) Peanut meal
        - 4) PABA is abundantly synthesized in the intestines.

4. Discuss with students the functions of other water-soluble vitamins, besides the B complex. Do they have similarities?

    What are the functions, deficiency symptoms, and important sources of other water-soluble vitamins?

    - a) Inositol
        - 1) Major functions
            - (a) In combination with choline, it prevents hardening of the arteries and protects the heart.
            - (b) Inositol helps reduce blood cholesterol.
        - 2) Deficiency symptoms are not demonstrated in animals.
        - 3) Good sources for animals
            - (a) Synthetic inositol
            - (b) Yeast
            - (c) Liver meal
        - 4) Additional comments
            - (a) Widely distributed in animal feeds
            - (b) Synthesized in the intestines
    - b) Niacin
        - 1) Major functions
            - (a) Constituent of two coenzymes, which are necessary in cell respiration
            - (b) Necessary to release energy from carbohydrates, fats, and protein
        - 2) Deficiency symptoms
            - (a) Often, there is reduced growth and appetite.
            - (b) Swine have diarrhea, vomiting, dermatitis, unthriftiness, and ulcerated intestines.
            - (c) Chicks show poor feathering and scaly dermatitis.
        - 3) Good sources for animals
            - (a) Synthetic niacin
            - (b) Meat and bone meal
            - (c) Green alfalfa
        - 4) Additional comments
            - (a) Niacin is a dietary essential for pigs, chickens, and humans.
            - (b) It is synthesized in the digestive tract of ruminants. Mature ruminants do not need dietary niacin under most conditions because of rumen bacteria.

            - (c) Niacin that is present in most cereal grains is not available to pigs and other simple-stomached animals.
    - c) Vitamin C (ascorbic acid)
        - 1) Major functions
            - (a) Necessary for collagen formation
            - (b) Absorption and movement of iron
            - (c) Metabolism of fats and lipids and cholesterol control
            - (d) Sound teeth and bones
            - (e) Strong capillary walls and healthy blood vessels
            - (f) More needed in periods of stress
        - 2) Deficiency symptoms
            - (a) Scurvy--swollen, bleeding, and ulcerated gums
            - (b) Loosening of teeth
            - (c) Weak bones
        - 3) Good sources for animals
            - (a) Vitamin C
            - (b) Citrus pulp
            - (c) Well-cured hay
            - (d) Green pasture
        - 4) Ordinary rations and body synthesis provide adequate vitamin C.

F. Other activities

1. Have students formulate a nutrition plan for various species, include the necessary vitamin supplements that would be needed, and justify the need.

2. Have a nutrition specialist speak to the class about the importance of vitamins in a ration.

G. Conclusion

Vitamins are organic compounds essential for life but needed only in trace amounts. Sixteen vitamins have been identified as essential in animal nutrition. They are classified by their solubility--either fat-soluble or water-soluble. Fat-soluble vitamins can be stored in the body, reducing the need for dietary sources. Water-soluble vitamins are not generally stored in the body and need to be supplied in the animal's diet. Vitamins play a vital role in various functions of the body's system and are an important part of the animal's overall nutrition.

H. Competency

Describe vitamins' role in nutrition.

I. Answers to Evaluation

1. j
2. b
3. a
4. d
5. i
6. g
7. h
8. e
9. c
10. f

11. Fat-soluble and water-soluble. Fat-soluble vitamins can be stored in the body, whereas water-soluble vitamins cannot. Therefore, the water-soluble vitamins must be supplied in the diet on daily basis.

UNIT I - NUTRITION

Name________________

Lesson 6: Vitamins' Role in Animal Nutrition

Date________________

EVALUATION

Match each vitamin on the right with the appropriate function on the left.

___ 1. Aids in assimilation and use of calcium and phosphorus; promotes normal bone development

___ 2. Essential for blood clotting

___ 3. Prevents night blindness; necessary for the maintenance of epithelial tissue

___ 4. Involved in red blood cell formation and in absorption of amino acids

___ 5. Maintains normal appetite, muscle tone and healthy mental attitude

___ 6. Component of coenzyme A; required for energy metabolism and of acyl carrier protein (ACP)

___ 7. Promotes growth and functions in the body as a constituent of several enzyme systems; is important in carbohydrate, fatty acid, and amino acid metabolism

___ 8. Necessary for cell respiration and in energy release from carbohydrates, fats, and protein

___ 9. Necessary for collagen formation and for iron absorption and movement

___ 10. Serves as a coenzyme for transferring CO_2 from one compound to another

a. Vitamin A

b. Vitamin K

c. Vitamin C

d. Vitamin B_6

e. Niacin

f. Biotin

g. Vitamin B_3 (pantothenic acid)

h. Vitamin B_2 (riboflavin)

i. Vitamin B_1 (thiamin)

j. Vitamin D

k. Vitamin B_{12}

Complete the following short answer question.

11. What are the two ways in which vitamins are classified?

Explain the differences between these ways.

UNIT I - NUTRITION

Lesson 7: Water's Role in Animal Nutrition

Objective: The student will be able to understand the function of water in animal nutrition.

Study Questions

1. **What is the function of water?**
2. **What are daily requirements for water?**
3. **What is water toxicity, and what are its symptoms?**
4. **What happens if there is an inadequate water supply?**

References

1. Student Reference

Lesson 7: Water's Role in Animal Nutrition

TEACHING PROCEDURES

A. Review

Review previous lesson on vitamins' role in animal nutrition.

B. Motivation

Why is water important to the human body? What happens when the human body is lacking water? Water makes up 50-75 percent of a human's weight. It helps in digestion, cell growth, chemical reactions, body temperature regulation, joint lubrication, and body structure and shape. Lack of water can cause kidney failure, fever, increased pulse rate, and flushed skin.

C. Assignment

D. Supervised study

E. Discussion

1. Ask students why water is so vital in the lives of humans. How many of these functions apply to livestock?

What is the function of water?

a) Important part of the body fluids
   1) Lubricates joints
   2) Lubricates eyes
   3) Acts as a cushion for nerves
   4) Helps conduct sound in the ear
   5) Helps dilute toxic substances, such as urea, and carry them through the digestive system (Urea is harmless to the urinary tract if it is diluted in water.)

b) Important part in the circulatory system
   1) Transfers heat from one part of the body to another, like a car radiator
   2) Cools the animal's body since animals do not have sweat glands to keep cool them like humans (They use evaporation of water to cool the body.)

c) Important part in gas exchange in the body
   1) Water vapor is mixed with other gases and expelled during respiration.
   2) Water is used in body temperature regulation.

d) Acts as a carrier in the mouth
   1) Carries chemicals in food to taste buds for the animal's recognition
   2) Aids in maintaining an animal's body shape
   3) Used in metabolism, digestion, and absorption of nutrients in the animal
   4) Essential in the bloodstream to carry and transport nutrients throughout the animal's body
   5) Aids in the elimination of waste products in the animal, usually in the urine and fecal material

2. See if students know what determines daily water requirements in livestock. Discuss which conditions change an animal's need for water.

What are daily requirements for water?

a) Daily requirements for livestock depend on the following:
    1) Species
    2) If the animal is lactating, since milk consists of 87 percent water
    3) Age, because younger animals require more water and have higher water content in their bodies
    4) Environmental temperature (Consumption increases when environmental temperatures increase.)
    5) The amount of exercise the animal gets (Water consumption increases as the animal becomes more active.)
    6) Moisture content of diet (Feeds with higher moisture content decrease the animal's free consumption.)
    7) Environmental humidity (As humidity increases, so does water consumption.)
    8) Level and kind of production of the animal (such as gestating, lactating, wool or meat producing)
    9) Mineral content of the animal diet (As the mineral content of the diet increases, so do the water requirements.)

b) Average daily requirements of livestock
    1) Beef cattle
        (a) Growing cattle
            (1) 100 lbs. = 1.5 gallons
            (2) 400 lbs. = 5 gallons
            (3) 800 lbs. = 7 gallons
        (b) Mature, fattening cattle = 9 gallons
        (c) Lactating = 10-15 gallons
    2) Lactating dairy cattle
        (a) Average production = 12-25 gallons
        (b) Heavy production = 35+ gallons
    3) Growing sheep
        (a) 20 lbs. = .5 gallon
        (b) 50 lbs. = .4 gallon
        (c) 150-200 lbs. = 1+ gallons
    4) Growing swine
        (a) 50 lbs. = 1+ gallons
        (b) 100 lbs. = 1.5+ gallons
    5) Mature swine
        (a) Pregnant = 5+ gallons
        (b) Lactating = 6+ gallons

c) Sources of water
    1) For drinking
        (a) Drinking water must be fresh, clean, and provided at all times for the animal's use.
        (b) Moisture in feed provides some water.
        (c) Fresh green pastures are 80 percent moisture.
        (d) Green cut forages, such as silage, have 65-75 percent moisture.
        (e) Dry harvested forages, such as hay, are 15 percent moisture.
        (f) Many grains, such as corn, have 10-15 percent moisture.
    2) From body metabolism
        (a) Some water is produced when fats, proteins, and carbohydrates are digested and metabolized.

91

        - (b) This source is impractical when figuring the animal's needs.

3. Ask students if they have ever heard of water toxicity. How do they know if an animal has acquired water toxicity?

   What is water toxicity, and what are its symptoms?

   - a) Water toxicity is dehydration accompanied by concentration of sodium and other ions in the brain cells that cause cerebral edema if:
     - 1) Thirsty animals are suddenly given fresh water.
     - 2) Dehydrated body tissues can't overcome the sudden overdose of water that the animal tries to drink to overcome its thirst.
     - 3) Toxicity is more common in calves or young animals because they try to drink 35-50 percent of total body water within a half hour period.
   - b) Symptoms of water toxicity
     - 1) Hemoglobinuria (red urine)
     - 2) Diarrhea
     - 3) Irregular heart beat
     - 4) Body hair stands on end
     - 5) Excessive salivation
     - 6) Extended position of the head and neck
     - 7) Fluids collecting in soft tissues under the skin; appears as apparently swollen eyelids
     - 8) Nervousness
       - (a) Animal's walk appears unstable.
       - (b) Excessive licking and rubbing occur.
     - 9) Coma, then death
   - c) Guidelines for treatment of water toxicity
     - 1) Administer saline or hypertonic glucose intravenously to remove excess water from body tissues.
     - 2) Give animal salt water.
     - 3) Be especially observant of animals if there was a lack of water for a long time.
     - 4) It takes 4-6 hours for water toxicity to be fatal.

4. Ask students what happens when there is insufficient water for humans. Is it the same for livestock?

   What happens if there is an inadequate water supply?

   - a) Occurrences in animals with low water intake
     - 1) Lack of appetite (eats less feed)
     - 2) Blood thickens
     - 3) Weight loss
     - 4) Reduction in performance and production
     - 5) Possible death by dehydration
   - b) Normal body functions that can increase water intake
     - 1) If animal develops scours or diarrhea, more water is needed. Water is lost because of a digestive disturbance.
     - 2) Through respiration, moist air is exhaled during respiration.
     - 3) When excess body heat leaves the animal's body through moist air, water is lost.

F. Other activities

Check with Extension and/or public health department employees for proper water sampling methods. Students can bring in water samples yearly for testing by Extension personnel. Contact the public health department for litmus paper testing (nitrogen) availability.

G. Conclusion

Understanding the roles of nutrients is vital for the management of livestock. A deficiency in one or more nutrients can cause severe losses in the production of livestock. Water is critical in maintaining all animal body functions; understanding this concept will lead to success as a livestock producer.

H. Competency

Describe the role of water in nutrition.

I. Answers to Evaluation

1. a
2. c
3. a

4. Six of the following:
   a) Lubricates joints
   b) Lubricates eyes
   c) Acts as a cushion for nerves
   d) Helps conduct sound in the ear
   e) Helps dilute toxic substances carry them through the digestive system
   f) Transfers heat from one part of the body to another
   g) Cools the animal's body by evaporation since animals do not have sweat glands to keep cool them like humans
   h) Mixes with other gases and expelled during respiration
   i) Used in body temperature regulation
   j) Carries chemicals in food to taste buds for the animal's recognition
   k) Aids in maintaining an animal's body shape
   l) Used in metabolism, digestion, and absorption of nutrients in the animal
   m) Essential in the bloodstream to carry and transport nutrients
   n) Aids in the elimination of waste products in the animal

5. Two of the following:
   a) Administer saline or hypertonic glucose intravenously to remove excess water from body tissues.
   b) Give animal salt water.
   c) Be especially observant of animals if there was a lack of water for a long time.

6. Two of the following:
   a) If animal develops scours or diarrhea
   b) Through respiration
   c) When excess body heat leaves the animal's body through moist air

UNIT I - NUTRITION Name__________________

Lesson 7: Water's Role in Animal Nutrition Date__________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which is NOT a symptom of water toxicity?

   a. Tail extension
   b. Coma
   c. Diarrhea
   d. Swollen eyelids

2. How long does it take for water toxicity to be fatal?

   a. 45 minutes
   b. 1-2 hours
   c. 4-6 hours
   d. 8 hours

3. Which is true regarding water?

   a. Water acts as a cushion for nerves within the body.
   b. Water produced by body metabolism is important in figuring an animal's water needs.
   c. Decreased environmental humidity increases the animal water consumption.
   d. Increased appetite is a sign of inadequate water supply.

Complete the following short answer questions.

4. List six functions of water.

   a.

   b.

   c.

   d.

   e.

   f.

5. List two treatments for water toxicity.

   a.

   b.

6. List two normal body functions that can increase water intake.

   a.

   b.

UNIT I - NUTRITION

Lesson 8: Environmental Effects on Nutrition

Objective: The student will be able to determine the environmental effects on animal nutrition.

Study Questions

1. **What is included in the animal's environment?**
2. **Identify weather factors that affect nutrition requirements and how animals react to them.**
3. **What are other factors affecting nutrition needs, and how do animals react?**
4. **How do feed requirements and production yields vary with temperature?**

References

1. Student Reference

UNIT I - NUTRITION

Lesson 8: Environmental Effects on Nutrition

TEACHING PROCEDURES

A. Review

Review previous lesson on water's role in animal nutrition.

B. Motivation

How does the environment affect human nutrient requirements? Wind chill, humidity, wind, and temperature strongly affect environmental conditions. Both hot and cold environments increase nutrient intake because it takes more calories to maintain body functions. Health, stress, and physical activity changes human nutrient requirements. How does the environment affect animal nutrient requirements? The same four environmental factors affect animal nutrient requirements--weather, stress, health, and nutrition.

C. Assignment

D. Supervised study

E. Discussion

1. Ask the students what factors are included in the animal's environment that can affect digestion and nutritional needs.

   What is included in the animal's environment?

   a) Everything surrounding and affecting the growth, development, and production of animals
   b) Involves nutrition, space requirements, light, relative humidity, air temperature and velocity, wet bedding, dust, ammonia buildup, odors, and manure disposal
   c) Factors with the most impact on nutritional needs
      1) Nutrition
      2) Weather and facilities/shelter
      3) Health
      4) Stress

2. Ask students to discuss what changes in the weather affect the nutritional needs of animals.

   Identify weather factors that affect nutrition requirements and how animals react to them.

   a) Weather is the "state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness and cloudiness." (Webster's dictionary)
   b) Animals have a thermo-neutral (comfort) zone.
   c) Extreme weather can cause wide fluctuations in animal performance.
   d) An animal's requirements increase as temperature, humidity, and wind exceed or fall short of its comfort zone. These three factors influence an animal's heat loss, as well.
   e) Animals adapt to cold weather by using various heating mechanisms.
      1) Increased insulation from hair growth and more fat

    2) Increased thyroid activity
    3) Seeking protective shelter and warming sunshine
    4) Huddling together
    5) *Consuming more feed, which increases the heat increment and warms the animal
    6) *Increasing activity

    NOTE: The most important heating mechanisms are noted with an asterisk (*).

  f) Animals adapt to hot weather by using the following cooling mechanisms.
    1) Moisture vaporization (from the skin and lungs)
    2) Avoidance of the sunshine
    3) Depression of thyroid activity
    4) Loafing
  g) Heat production (metabolism) is plotted against ambient temperature to depict the relationship between chemical and physical heat regulation.
  h) Rain reduces feed intake by 10-30 percent and mud by 5-30 percent, depending upon its depth and the amount of bedded area.
  i) There are several ways in which animals cope with inclement weather.
    1) Environmentally controlled buildings
    2) Adaptation
      (a) Brahman cattle are more heat tolerant.
      (b) British breeds, such as Herefords, are more cold tolerant.
    3) Increased or decreased nutrient needs

3. Have students discuss factors, other than the weather, that change nutrient requirements of animals.

What are other factors affecting nutritional needs, and how do animals react?

  a) Gestation
    1) Nutrient requirements for pregnant females are most critical during the last trimester, when the developing fetus grows most.
    2) Especially critical are nutrient requirements for young females during their first pregnancy. Poor nutrition at this stage will result in a poorly developed fetus and poor growth of the mother.
  b) Lactation
    1) Milk production requires a liberal supply of energy, protein, minerals, and vitamins in the ration.
    2) After giving birth, feed requirements increase tremendously because of milk production.
    3) A female suckling young needs approximately 50 percent greater feed allowance than during the pregnancy period.
  c) Stress
    1) Any environmental factor that is counter-productive to an animal's well-being, either external or internal
    2) The more the stress, the more nutrition that is needed
    3) Kinds of stress
      (a) Excitement
      (b) Presence of strangers
      (c) Changing animals that are together
      (d) Crowding
      (e) Disease
      (f) Hauling
      (g) How animals are handled
      (h) Weaning

98

        4) Handling that reduces stress
            (a) Preconditioning (started on feed, vaccinated, etc.) before weaning
            (b) Proper handling during vaccinations, movement, and hauling
    d) Health
        1) In the U.S., animal diseases and parasites decrease animal productivity by 15-20 percent.
        2) Improper nutrition has some involvement in up to 85 percent of cases treated by veterinarians.
    e) Muddy lots
        1) Mud increases scours and other diseases in newborn animals; in older animals, it reduces production and feed efficiency.
        2) Studies show that mud can reduce finishing cattle gains *and* increase the feed required per pound of gain by as much as 10-35 percent. (California Agricultural Experiment Station)
        3) These problems can be minimized by proper management.
            (a) Lots that are properly located and constructed for proper drainage
            (b) Mounds that are 6-12 feet high as a dry place on which cattle can lie
            (c) Lessening the number of cattle in the lots during the muddy seasons

4. Ask the students how nutritional requirements might change when animals are subjected to any of the above factors.

How do feed requirements and production yields vary with temperature?

    a) Dairy cows
        1) The optimum temperature for the production of milk is 55-64°F.
        2) Temperatures below optimum
            (a) Reduction of water intake
            (b) Approximately 35 percent increase in feed intake (down to -4°F)
            (c) Corresponding decrease in milk yield
            (d) Can be corrected by increasing the proportion of concentrate in the diet (20 percent roughage/80 percent concentrate) and providing shelter
            (e) Better maintained milk yields with higher concentrate levels
        3) Temperatures above optimum cause:
            (a) Increase in water intake
            (b) Decrease in feed intake at 77-81°F, with greater decrease above 85°F
            (c) Decrease in dry-matter intake
            (d) Corresponding decrease in milk yield
            (e) At 95°F, milk yield reduced as much as 33 percent
            (f) Impact of environmental extremes reduced by using confined housing for lactating dairy cows
    b) Beef cattle
        1) The temperature range of 59-77°F is considered optimum.
        2) Variations from this range change feed intake.
            (a) At 77-95°F, feed intake depressed 3-10 percent
            (b) At 41-59°F, feed intake increased 2-5 percent
            (c) At 23-41°F, feed intake increased 3-8 percent
            (d) At 5-25°F, feed intake increased 5-10 percent
            (e) Below 5°F, feed intake increased 8-25 percent
        3) During cold weather, increase the amount of roughage for cattle on restricted feed intake.
        4) With cattle on full feed, increasing the amount of roughage during cold weather can actually *decrease* the amount of energy available.

c) Sheep
  1) There is little data available that describes the interaction of temperature and feed intake for sheep.
  2) Sheep can tolerate colder climatic extremes than other animals.
  3) The length of the fleece and the level of feeding affect feed intake as temperatures change.
  4) Sheep need higher energy intake during cold stress. This can be done economically by increasing the roughage in the ration.
  5) During hot weather, decrease the roughage; this lowers the amount of heat produced by digesting the feed.

d) Swine
  1) A temperature range of 64-70°F is considered optimum for growing/finishing swine.
  2) For each 1.8°F of temperature drop, the feed requirement increases 1-1.4 oz. daily.
  3) Heavier hogs are more sensitive to hot weather than lighter hogs.

e) Poultry
  1) Laying hens can adjust to a fairly wide range of temperatures. When the temperature change occurs, feed intake will change temporarily and then return to approximately the level before the temperature change.
  2) Adequate drinking water is more critical to maintaining growth or production in poultry. Compared to water intake at 70°F, water intake is doubled at 90°F and is 2.5 times greater at 98°F.

F. Other activities

1. Have the class chart the various weather factors including precipitation, wind, temperature, and humidity for a length of time (week, month, etc.). Then, for a specific species, identify changes that would need to be made in feeding, handling, etc., according to the changes in weather.

2. Have the students further research animal behaviors. Have them choose a species or a behavior to write papers that describe the behavior, affect on the animal, and ways to adjust or handle the situations that occur.

G. Conclusion

Livestock nutrient requirement tables are generally based on the assumption that no environmental stress is present. Feed and nutritional requirements need adjusting for changes in the animal's environment. Efficiency of nutrient use is affected by the weather, stress, health, and facilities.

H. Competency

Describe environmental effects on nutrition.

I. Answers to Evaluation

1. Three of the following:
   Nutrition, weather and facilities/shelter, health, stress

2. Four of the following:
   a. Increased insulation from growth of hair and more subcutaneous fat
   b. Increase in thyroid activity
   c. Seeking protective shelter and sunshine

   - d. Huddling together
   - e. Consumption of more feed
   - f. Increasing activity

3. Three of the following:
   - a. Moisture vaporization
   - b. Avoidance of the sunlight (seeking shade)
   - c. Depression of thyroid activity
   - d. Loafing (decreased activity and production)

4. Three of the following: gestation, lactation, stress, health, muddy lots

5. Two of the following:
   - a. Mounds
   - b. Proper drainage
   - c. Decreased number in the lot

6. d
7. a
8. c

Name____________________

Lesson 8: Environmental Effects on Nutrition

Date____________________

EVALUATION

Complete the following short answer questions.

1. List three of the four factors that affect nutritional needs the most.

   a.

   b.

   c.

2. Name four of the heating mechanisms employed by animals during cold weather.

   a.

   b.

   c.

   d.

3. Name three cooling mechanisms employed by animals during hot weather.

   a.

   b.

   c.

4. Name three factors, other than the weather, that affect nutritional requirements.

   a.

   b.

   c.

5. Give two ways in which the stress of a muddy lot can be alleviated.

   a.

   b.

Circle the letter that corresponds to the best answer.

6. Which class of livestock can adjust to widely ranging temperature variations?

   a. Dairy
   b. Beef
   c. Swine
   d. Poultry

7. For milk production, which is the optimum temperature range for dairy cattle?

   a. 55-64°F
   b. 59-77°F
   c. 64-70°F
   d. 70-77°F

8. Which is the optimum temperature range for finishing swine?

   a. 55-64°F
   b. 59-77°F
   c. 64-70°F
   d. 70-77°F

UNIT I - NUTRITION

Lesson 9: Formulating and Balancing Rations

Objective: The student will be able to formulate a ration for livestock at the teacher's discretion.

Study Questions

1. **What are the general principles in formulating a ration?**
2. **What are the steps in balancing a ration?**
3. **What are eight essentials to balancing a ration?**

References

1. Student Reference
2. Activity Sheet
    a) AS 9.1: Formulating Rations

UNIT I - NUTRITION

Lesson 9: Formulating and Balancing Rations

TEACHING PROCEDURES

A. Review

Review Pearson Square computation from Agricultural Science core curriculum.

B. Motivation

Ask the students how they decide what foods to eat during a given day. Are there guidelines about fixing certain foods together for a meal? (Yes--Food Pyramid)

C. Assignment

D. Supervised study

E. Discussion

1. Ask students what they believe are the components of a good livestock ration. How do you decide what feed to use in a feeding program?

What are the general principles in formulating a ration?

a) Diet must meet the nutritional needs of the animal.
    1) Nutrient requirements are listed in tables usually available from the National Research Council.
    2) Balanced rations have nutrient allowances that are only 1-3 percent below the animal's requirement.

b) Diets must include a minimum level of dry matter for proper digestive tract functioning.

c) Diets are commonly balanced to meet the protein, energy, calcium, phosphorus, and vitamin A requirements for the animal.
    1) Protein
        (a) The amount of protein in the diet can be measured by crude protein (CP) or digestible protein (DP) content.
        (b) In diets balanced for nonruminants, essential amino acids must be considered.
        (c) Protein is an expensive part of the diet; using unneeded amounts raises the cost of the ration excessively.
    2) Energy
        (a) Four measures of energy are commonly used when formulating diets.
            (1) Digestible energy (DE)
            (2) Total digestible nutrients (TDN)
            (3) Metabolizing energy (ME)
            (4) Net energy (NE)
        (b) Energy provided in the diet should not be more than about five percent above requirements because animals are limited in the total amount of energy they can use.

3) Minerals
    (a) Calcium (Ca) and phosphorus (P) are the two minerals generally needed in larger amounts.
    (b) The ratio of Ca to P should be between 1:1 and 2:1.
    (c) There are usually enough minerals provided in the ingredients used or by the addition of trace-mineralized salt.

4) Vitamins
    (a) A vitamin supplement is usually added to the ration to meet the vitamin needs of the animal.
    (b) Always add a vitamin supplement to a gestation ration.
    (c) Sheep and cattle fed low-quality legume hay during pregnancy might exhibit symptoms of vitamin deficiency.

d) Cost of nutrients
    1) The cost per pound of each nutrient must be considered when developing least-cost rations for maximum efficiency.
    2) Energy and protein nutrients are the major ones to consider when making nutrient cost comparisons.

2. Ask the students how they would decide on a ration's components. Ask students what characteristics are important to consider when balancing a ration.

What are the steps in balancing a ration?

a) Identify the kind, age, weight, and function of the animal for which the ration is being formulated.
b) Consult a table of nutrient requirements to determine the nutrient needs of the animal.
c) Choose the feeds to be used in the ration and consult a feed composition table to determine the nutrient content of the selected feeds.
d) Calculate the amounts of each feed to use in the ration.
    1) Pearson square
    2) Algebraic equations
    3) Computer programs
e) Check the ration formulated against the needs of the animal. Be sure it meets the requirements for vitamins and minerals.
f) Check the cost of the nutrients in the ration to determine if this is the most economical, practical ration.

3. Ask the students about what they feel are essentials to a good ration.

What are the eight essentials to balancing a ration?

a) Nutrients in the ration should be balanced. Faster gains, less expense, and more profits are realized when feeding balanced rations.
b) The ration should contain a variety of feeds. This variety generally increases the palatability of the ration and makes it easier to balance the nutrients.
c) The ration should be fresh and appealing. Livestock consume more of a fresh ration, thus increasing productivity.
d) A ration should be palatable (agreeable to the taste).
e) The ration should be bulky; one containing a bulky feed (ground oats, beet pulp, etc.) usually is more desirable.
f) A ration should be slightly laxative. A laxative ration usually improves efficiency.
g) The ration should be economical. Low-cost, high-quality rations keep the producer in business.

h) The ration should be suited to the animal. Digestive systems are different among species. Cattle and sheep can consume large quantities of roughage, while poultry and swine rations must consist of largely concentrates.

F. Other activities

1. In conjunction with the activity sheet, use raw ingredients to make feed.

2. Computer programs

   a) Stallings, Charlie, et. al. *DAIR4* (IBM dairy and beef program). Blacksburg, VA: Virginia Tech. (Can be downloaded from Agriculture Electronic BBS, 573/882-8289, system operator 573/882-4827)
   b) *Taurus* (IBM cattle ration program). University of California-Davis, 1990.
   c) *Apollo* (IBM swine ration program). University of California-Davis, 1990.

3. Show the slides, *Horse Feeding and Nutrition* (AG SL 23), available from the Missouri Vocational Resource Center.

G. Conclusion

This lesson will help students understand and compute basic nutritional needs for different classes of livestock. For growth to occur, every one of the five nutrients (protein, energy, minerals, vitamins, and water) must be present in sufficient quantity.

H. Competency

Formulate a ration for different classes of livestock.

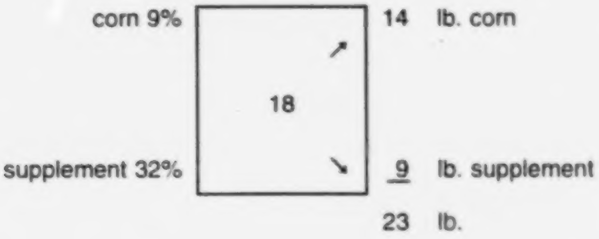
I. Answers to Evaluation

1. d
2. b
3. a
4. a, c, d, e (question worth eight points)
5. a, b, c, e, f, g (question worth eight points)

J. Answers to Activity Sheet 9.1

1. Example using problem 1 and the Pearson Square

Step 1: Construct a square with percent crude protein in the center of the square. Put the two feed ingredients in the corners on the left side. Diagonally subtract the smaller number from the larger number (18 - 9 = 9 and 32 - 18 = 14). Add the two remainders together (9 + 14 = 23).



Step 2: Write the "9" and "14" on the square. Therefore, in 23 lbs. of feed, there are 14 lbs. of corn and 9 lbs. of supplement.

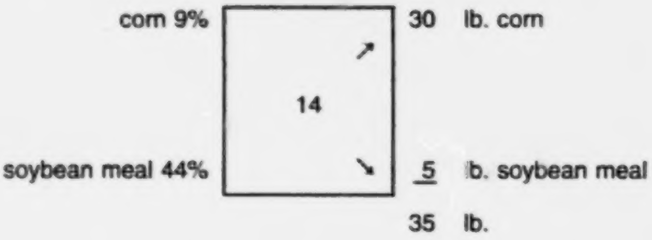
Step 3: To determine the ton mixture, divide by 2000 lbs. to calculate the percentage of each feed in the mixture. Round to one decimal place.

$^{14}/_{23}$ = .608 or 61% x 2000 = 1217.4 lbs. of corn
$^{9}/_{23}$ = .391 or 39% x 2000 = 782.6 lbs. of supplement
2000.0 lbs. (ton)

Step 4: Check the mixture for protein content.
1217.4 lbs. of corn x .09 = 109.6
782.6 lbs. of supplement x .32 = 250.4
360.0

Step 5: To get a 100 lb. ration from the 2000 lb. figures, divide by 20 (360 ÷ 20 = 18%). This ration is balanced for crude protein only. The ration must be checked for energy, minerals, and vitamins. Adjustments must be made to meet animal requirements and to be a complete, balanced ration.

2. *Step 1:* 14 - 9 = 5 and 44 - 14 = 30; 5 + 30 = 35

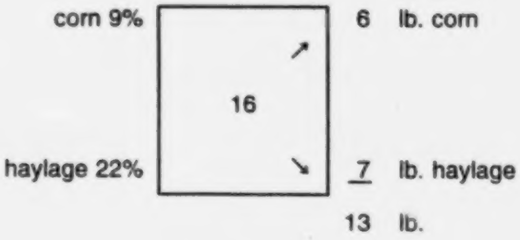


Step 2: In 35 lbs. of feed, there are 30 lbs. of corn and 5 lbs. of soybean meal.

Step 3: $^{30}/_{35}$ = .857 or 86% x 100 = 85.7 lbs. of corn
$^{5}/_{35}$ =.142 or 14% x 100 = 14.3 lbs. of soybean meal
100.0 lb. ration

Step 4: Check the mixture for protein content.
85.7 lbs. of corn x .09 = 7.71
14.3 lbs. of soybean meal x .44 = 6.29
14%. This ration is balanced for crude protein.

3. *Step 1:* 16 - 9 = 7 and 22 - 16 = 6; 6 + 7 = 13



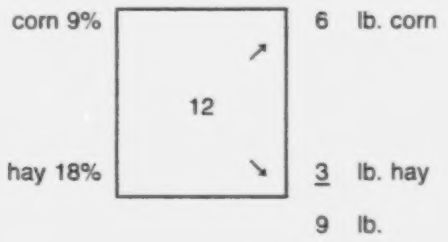
Step 2: In 13 lbs. of feed, there are 7 lbs. of corn and 6 lbs. of haylage.

Step 3:
$^{7}/_{13}$ = .538 or 54% x 4000 = 2153.8 lbs. of corn
$^{6}/_{13}$ = .461 or 46% x 4000 = $\underline{1846.2}$ lbs. of haylage
4000.0 lbs.

Step 4: Check the mixture for protein content.
2153.8 lbs. of corn x .09 = 193.84
1846.2 lbs. of haylage x .22 = $\underline{406.16}$
600.00

Step 5: 600 ÷ 40 = 15%. Ration is balanced for crude protein.

4. *Step 1:* 12 - 9 = 3 and 18 - 12 = 6; 6 + 3 = 9


corn 9%
hay 18%
12
6 lb. corn
3 lb. hay
9 lb.

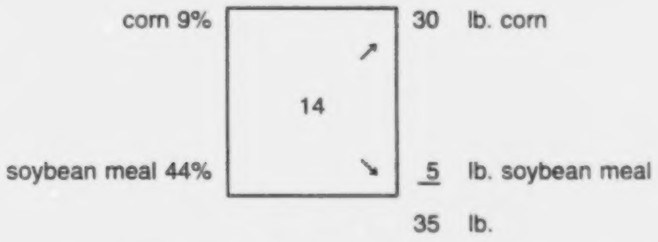
Step 2: In 9 lbs. of feed, there are 6 lbs. of corn and 3 lbs. of hay.

Step 3:
$^{6}/_{9}$ = .666 or 67% x 500 = 333.33 lbs. of corn
$^{3}/_{9}$ = .333 or 33% x 500 = $\underline{166.66}$ lbs. of supplement
499.99 (500) lbs.

Step 4: Check the mixture for protein content.
333.33 lbs. of corn x .09 = 29.99
166.66 lbs. of hay x .18 = $\underline{29.99}$
59.98 (60)

Step 5: 60 ÷ 5 = 12%. This ration is balanced for crude protein only.

5. *Step 1:* 14 - 9 = 5 and 44 - 14 = 30; 30 + 5 = 35


corn 9%
soybean meal 44%
14
30 lb. corn
5 lb. soybean meal
35 lb.

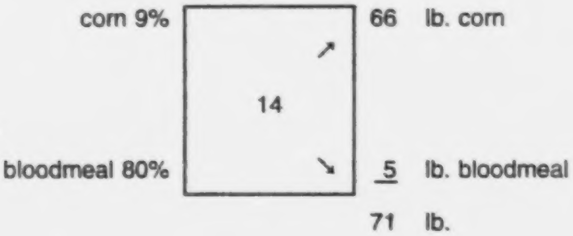
Step 2: In 35 lbs. of feed, there are 30 lbs. of corn and 5 lbs. of soybean meal.

Step 3: $^{30}/_{35}$ = .859 or 86% x 800 = 685.7 lbs. of corn
$^{5}/_{35}$ = .142 or 14% x 800 = 114.3 lbs. of soybean meal
800.0 lbs.

Step 4: Check the mixture for protein content.
685.7 lbs. of corn x .09 = 61.71
114.3 lbs. of soybean meal x .44 = 50.29
112.0

Step 5: 112 ÷ 8 = 14%. This ration is balanced for crude protein only.

6. *Step 1:* 14 - 9 = 5 and 80 - 14 = 66; 66 + 5 = 71



Step 2: In 71 lbs. of feed, there are 66 lbs. of corn and 5 lbs. of bloodmeal.

Step 3: $^{66}/_{71}$ = .929 or 93% x 10,000 = 9295.8 lbs. of corn
$^{5}/_{71}$ = .070 or 7% x 10,000 = 704.2 lbs. of bloodmeal
10,000.0 lbs.

Step 4: Check the mixture for protein content.
9295.8 lbs. of corn x .09 = 836.62
704.2 lbs. of bloodmeal x .80 = 563.36
1399.98

Step 5: 1400 ÷ 100 = 14%. This ration is balanced for crude protein only.

UNIT - NUTRITION

Lesson 9: Formulating and Balancing Rations

Date__________________

Name__________________

EVALUATION

Circle the letter that corresponds to the best answer.

1. What two minerals are needed in the greatest quantities in most livestock rations?

   a. Zinc and boron
   b. Zinc and phosphorus
   c. Boron and calcium
   d. Calcium and phosphorus

2. Amino acids have the greatest influence when figuring a ration for which type of livestock?

   a. Ruminants
   b. Nonruminants
   c. Modified nonruminants
   d. Avians

3. Energy provided in the diet or ration should not exceed what percentage over the animal's requirements?

   a. Five
   b. Eight
   c. Ten
   d. Twenty

Complete the following multiple answer questions.

4. Check the physical traits needed to formulate a ration.

   ____ a. Age
   ____ b. Height
   ____ c. Weight
   ____ d. Type of livestock
   ____ e. Level of production
   ____ f. Hair color
   ____ g. Conformation score
   ____ h. Polled or horned
   ____ i. Breed
   ____ j. Environmental conditions

5. Check the essentials for balancing a ration

   ____ a. Cost
   ____ b. Palatability
   ____ c. Feedstuff variety
   ____ d. Cheapest possible ration
   ____ e. Slightly laxative
   ____ f. Match type of animal
   ____ g. Low-cost, high-quality ration
   ____ h. Fewest number of ingredients

Lesson 9: Formulating and Balancing Rations

Name________________

FORMULATING RATIONS

Complete the following short answer questions. State whether each ration is balanced for crude protein.

1. Formulate an 18 percent protein ration for a 100 lb. hog. Feedstuffs used are corn at 9 percent and a 32 percent protein supplement. Figure a 1 ton ration.

2. Formulate a 14 percent protein ration for a 180 lb. hog. Feedstuffs used are corn @ 9 percent protein and soybean meal at 44 percent protein. Figure a 100 lb. ration.

3. Formulate a dairy 16 percent protein ration for a 1200 lb. lactating cow using the feedstuffs of 22 percent protein in alfalfa haylage and 9 percent protein in corn. Figure a 2 ton ration.

4. Formulate a dairy 12 percent protein ration for a 1200 lb. dry cow using 18 percent protein in alfalfa hay and 9 percent protein in corn. Figure a 500 lb. ration.

5. Formulate a sheep 14 percent protein ration for an 80 lb. market lamb using feedstuffs of 9 percent protein in corn and 44 percent protein in soybean meal. Figure an 800 lb. ration.

6. Formulate a 14 percent protein ration for an 800 lb. beef steer using 9 percent protein corn silage and 80 percent protein in bloodmeal. Figure a 5 ton ration.

UNIT II - GENETICS

Lesson 1: Importance of Genetics in Agriculture

Objective: The student will be able to describe the importance of an animal's genetic makeup and its effect on agriculture.

Study Questions

1. **What careers are associated with livestock genetics?**
2. **What is the economic importance of genetics in livestock?**
3. **How has genetic selection of animals changed over the years?**

References

1. Student Reference
2. Activity Sheets
    a) AS 1.1: Heritability Traits
    b) AS 1.2: Beef Herd Selection

UNIT II - GENETICS

Lesson 1: Importance of Genetics in Agriculture

TEACHING PROCEDURES

A. Review

Review the previous unit on animal nutrition.

B. Motivation

1. How was the color of your eyes or hair determined? How can you predict if you will become bald? All these characteristics can be determined through genetics. Knowing your parents' dominant or recessive genes and if their chromosomes are homozygous or heterozygous, you can foretell baldness, eye color, and hair color.

   The same principle applies to livestock. Genetics influences economic traits in livestock more than in humans. If rate of gain is influenced 40% by genetics, producers can genetically improve rate of gain in a herd by selecting a sire with a high rate of gain.

2. In the same way, color of hair coat, polled or horned characteristics, and dwarfism can be determined in animals. As with humans, determining recessive and dominant genes in the parents aids in determining these factors before birth. It is also important to know if chromosomes are homozygous or heterozygous. Review the checker board to determine genetic outcomes.

SIRE

		P	P
DAM	p	Pp	Pp
	p	Pp	Pp

KEY: P = Dominant gene
p = Recessive gene
PP = Homozygous
pp = Heterozygous

C. Assignment

1. Have students write down environmental factors that affected each trait for each class of livestock. An example would be that 75% of milk production is influenced by environmental factors. Some of these might be environmental temperature, humidity, diet, and age.

2. Compare and contrast the different classes of livestock, picking important traits used in animal selection. An example of traits that are heavily influenced by heritability is percent butterfat and percent protein found in milk. Meanwhile, feet and legs have a low heritability, so feet and leg development is more influenced by environment.

D. Supervised study

E. Discussion

1. See if students can associate occupations with animal genetics. Discuss the educational and experience requirements needed for various occupations.

   What careers are associated with livestock genetics?

   a) Production
      1) Farm manager
      2) Animal breeder
      3) Dairy herd owner
      4) Horse rancher
      5) Cattle rancher
      6) Sheep rancher
      7) Swine producer
      8) Poultry producer
      9) Specialty animal breeder
   b) Supplies and services
      1) Veterinarian
      2) Artificial breeding technician
      3) Veterinarian assistant
      4) Ova transplant specialist
      5) Breeding services representative
      6) Breed association employee
      7) Field sales representative for animal breeding products
      8) Artificial inseminator
      9) Cloning technician
      10) Embryo transfer technician
   c) These are only a few occupations in livestock genetics. This field of agriculture is growing rapidly because of new breeding technologies such as cloning, AI, and embryo transfer. Occupations in the supplies and service area require a rigorous academic background for employment. Production occupations need a good academic foundation but use work experience to determine qualifications for a job.

2. What is meant by a trait that has economic importance?

   What is the economic importance of genetics in livestock?

   a) Beef cattle traits affected by heritability
      NOTE: (M) = management trait, (Ph) = physical trait, and (Pr) = production trait
      1) (M) Calving interval or fertility has 10% heritability to offspring and 90% environment.
      2) (M) Birth weight has 40% heritability to offspring and 60% environment.
      3) (Pr) Weaning weight has 30% heritability to offspring and 70% environment.
      4) (M) Cow maternal ability has 40% heritability to offspring and 60% environment.
      5) (Pr) Feedlot gain has 45% heritability to offspring and 55% environment.
      6) (Pr) Pasture gain has 30% heritability to offspring and 70% environment.
      7) (Pr) Efficiency of gain has 40% heritability to offspring and 60% environment.
      8) (Pr) Final feedlot weight has 60% heritability to offspring and 40% environment.
      9) (Ph) Conformation score has heritability of 25% at weaning and 40% at slaughter.
      10) (Pr) Carcass trait heritability is 40% carcass grade, 70% rib eye area, 60% tenderness, and 45% fat thickness.
      11) (Ph) Cancer eye susceptibility has 30% heritability to offspring and 70% environment.

- b) Dairy cattle traits affected by heritability
    - 1) (Pr) Milk production has 25% heritability to offspring and 75% environment.
    - 2) (Pr) Percent fat has 50% heritability to offspring and 50% environment.
    - 3) (Pr) Percent protein has 50% heritability to offspring and 50% environment.
    - 4) (Pr) Percent of soluble nitrogen-free extracts (soluble fats) has 50% heritability to offspring and 50% environment.
    - 5) (Pr) Feed lot gain has 45% heritability to offspring and 55% environment.
    - 6) (Ph) Stature has 40% heritability to offspring and 60% environment.
    - 7) (Ph) Udder support has 20% heritability to offspring and 80% environment.
    - 8) (Ph) Legs and feet have 15% heritability to offspring and 85% environment.
    - 9) (Pr) Milking speed has 25% heritability to offspring and 75% environment.
    - 10) (M) Birth weight has 40% heritability to offspring and 60% environment.
    - 11) (M) Temperament has 40% heritability to offspring and 60% environment.
    - 12) (M) Fertility has 5% heritability to offspring and 95% environment.
- c) Sheep traits affected by heritability
    - 1) (M) Multiple births have 15% heritability to offspring and 85% environment.
    - 2) (M) Birth weights have 30% heritability to offspring and 70% environment.
    - 3) (Pr) Weaning weight heritability to offspring is 10% at 60 days and 30% at 100 days.
    - 4) (Pr) Rate of gain has 30% heritability to offspring and 70% environment.
    - 5) (Ph) Type score has 10% for weanling and 40% for yearling heritability to offspring.
    - 6) (Pr) Finish or condition at weaning has 17% heritability to offspring and 83% environment.
    - 7) (Ph) Wrinkles or skin folds have 39% for neck folds and 40% for body folds heritability to offspring.
    - 8) (Ph) Face covering has 56% heritability to offspring and 44% environment.
    - 9) (Pr) Fleece weight has 38% grease weight and 40% clean weight heritability to offspring.
    - 10) (Pr) Staple length has 39% for weanling and 47% for yearling heritability to offspring.
    - 11) (Pr) Fleece grade has 35% heritability to offspring and 65% environment.
    - 12) (Pr) Fat thickness over loin eye has 35% heritability to offspring and 65% environment.
    - 13) (Pr) Loin eye area has 53% heritability to offspring and 47% environment.
    - 14) (Pr) Carcass weight/day of age has 22% heritability to offspring and 78% environment.
    - 15) (Pr) Carcass grade has 12% heritability to offspring and 88% environment.
    - 16) (Pr) Carcass length has 31% heritability to offspring and 69% environment.
- d) Swine traits affected by heritability
    - 1) (M) Litter size at birth has 15% heritability to offspring and 85% environment.
    - 2) (M) Litter size at weaning has 12% heritability to offspring and 88% environment.
    - 3) (M) Birth weight of pigs has 5% heritability to offspring and 95% environment.
    - 4) (Pr) Litter weight at weaning has 15% heritability to offspring and 85% environment.
    - 5) (Pr) Daily rate of gain from weaning to market has 40% heritability to offspring and 60% environment.
    - 6) (Pr) Days to 230 lbs. has 35% heritability to offspring and 65% environment.
    - 7) (Pr) Efficiency of feed utilization has 30% heritability to offspring and 70% environment.
    - 8) (Ph) Conformation score has 29% heritability to offspring and 71% environment.
    - 9) (Pr) Carcass characteristic heritability is 60% on length, 40% on back-fat thickness, 50% on loin muscle area, 58% on predicted percent lean, and 50% percent lean cuts to offspring.

3. What is meant by genetic selection in livestock? Discuss how this type of selection has changed over time.

How has genetic selection of animals changed over the years?

- a) Traditionally, animals were selected from physical traits. Management and production records were not kept or available. Animals were selected by the type of individual, its pedigree, and by show-ring winnings. Now, there is an abundance of production, physical, and management records kept on animals, especially purebred and show animals. These records have introduced the latest selection method--production testing.
- b) Today, animal selection is based on three types of testing:
  - 1) Performance testing--the practice of evaluating and selecting animals on their merit or performance
  - 2) Progeny testing--the practice of selecting animals on the merit of their progeny (offspring)
  - 3) Production testing--involves the taking of accurate records of both performance and progeny, rather than casual observations.
    - (a) Includes systematic measurement of differences in economically important traits, recording these differences, and using them in selection
    - (b) A selection tool used to increase the rate of genetic improvement in individual herds
    - (c) Used to compare animals that are handled alike. Not reliable in comparing herds--just individuals (This method is used to cull animals that seem alike but perform differently.)

F. Other activities

AS 1.1 is a pretest for students' knowledge of EPDs. EPDs will be covered more extensively in Lesson 5, but students can classify the traits on AS 1.1 for physical, production, or management traits. Ask students what other traits might influence their selection of a sire.

G. Conclusion

It is vital for livestock producers and others in livestock-related occupations to understand economic traits associated with genetics and to select livestock based on genetic improvement.

H. Competency

Describe the importance of genetics on agriculture.

Related Missouri Core Competencies and Key Skills

10C-1: Predict the phenotypic and genotypic ratios of the offspring of a dihybrid cross using a Punnett square.
10C-4: Associate the roles of genetic variation and natural selection with change in organisms over time.

I. Answers to Evaluation

1. a
2. b
3. c
4. c
5. a
6. a
7. b
8. c
9. c
10. b
11. a
12. c
13. b
14. a
15. c
16. c
17. b
18. a
19. c
20. a

21. Any five of the following:
Farm manager
Animal breeder
Dairy herd producer
Horse rancher
Cattle rancher
Sheep rancher
Swine producer
Poultry producer
Specialty animal breeder

22. Any five of the following:
Supplies and services
Veterinarian
Artificial breeding technician
Veterinarian assistant
Ova transplant specialist
Breeding services representative
Breed association employee
Field sales representative for animal breeding products
Artificial inseminator
Cloning technician
Embryo transfer technician

23. a, c, d, e (question worth six points)

J. Answers to Activity Sheets

AS 1.1

1. (Pr) Percent fat - High
(Pr) Percent protein - High
(Pr) Percent soluble NFE - High
(Pr) Feed lot gain - Medium
(Ph) Stature - Medium
(Ph) Udder support - Low
(Ph) Legs and Feet - Low
(Pr) Milking speed - Medium
(M) Birth weight - Medium
(M) Temperament - Medium
(M) Fertility - Low

2. (M) Calving interval or fertility - Low
(M) Birth weight - Medium
(Pr) Weaning weight - Medium
(M) Maternal ability - Medium
(Pr) Feed lot gain - Medium
(Pr) Pasture gain - Medium
(Pr) Efficiency of gain - Medium
(Pr) Final feedlot weight - High
(Ph) Conformation score - Medium
(Pr) Carcass grade - Medium
(Pr) Ribeye area - High
(Pr) Tenderness - High

(Pr) Fat thickness - Medium
(Ph) Cancer eye susceptibility - Medium

3. (M) Litter size at birth - Low
(M) Litter size at weaning - Low
(M) Birth weight - Medium
(Pr) Litter weight at weaning - Low
(Pr) Daily rate of gain - Medium
(Pr) Days to 230 pounds - Medium
(Pr) Efficiency of feed utilization - Medium
(Ph) Conformation score - Medium
(Pr) Carcass length - High
(Pr) Back fat thickness - Medium
(Pr) Loin area muscle - High
(Pr) Predicted percent lean - High
(Pr) Percent lean cuts - High

4. (M) Multiple births - Low
(M) Birth weight - Medium
(Pr) Weaning weight 60 days - Low
(Pr) Type score weaning - Low yearling - Low
(Pr) Finish or condition at weaning - Low
(Ph) Wrinkles or skin folds - Medium
(Ph) Face covering - High
(Pr) Fleece weight - Medium
(Pr) Staple length - Medium
(Pr) Fleece grade - Medium
(Pr) Fat thickness over loin eye - Medium
(Pr) Loin eye area - High
(Pr) Carcass weight/day of age - Low
(Pr) Carcass grade - Low
(Pr) Carcass length - Medium

AS 1.2

1. Bull 1. The herd females are yearling heifers, which have not reached their mature weight and size. Bull 1 will produce a smaller or average size calf. Bull 2 could result in pulling a large percentage of calves, which adds to production expense and risk.

UNIT II - GENETICS Name_______________

Lesson 1: Importance of Genetics in Agriculture Date_______________

EVALUATION

In the following list of livestock heritability traits, place the appropriate letter in the space provided to indicate if it is a management, physical, or production trait.

A = management trait, B = physical trait, C = production trait

1. _____ Fertility
2. _____ Udder support
3. _____ Rate of gain
4. _____ Weaning weights
5. _____ Birth weights
6. _____ Temperament
7. _____ Stature
8. _____ Fat thickness
9. _____ Loin eye area
10. _____ Face covering
11. _____ Maternal ability
12. _____ Carcass grade
13. _____ Leg and feet
14. _____ Milking speed
15. _____ Fleece weight
16. _____ Pasture gain
17. _____ Wrinkles or skin folds
18. _____ Multiple births
19. _____ Carcass length
20. _____ Litter size

Complete the following short answer questions.

21. List five production occupations involved with livestock genetics.

    a.

    b.

    c.

    d.

    e.

22. List five genetics occupations in the supplies and service area.

a.

b.

c.

d.

e.

23. Check the factors associated with production testing of livestock.

____ a. Used to increase the rate of genetic improvement within an individual herd
____ b. Used to compare different herds
____ c. Used to compare animals within a herd handled alike
____ d. Uses a systematic measurement of differences between economically important traits
____ e. Accurate and precise records must be kept.
____ f. Used just for casual observation

Lesson 1: Importance of Genetics in Agriculture Date__________________

HERITABILITY TRAITS

List the heritability traits for dairy, beef, swine, and sheep. Rate each trait as to which you would consider influenced highly, moderately, or slightly by genetics (0-24% = low, 25-49% = moderate, 50% and above = high). Indicate which type of trait it is (Pr = production, Ph = physical, and M = management).

1. Dairy cattle:

   EXAMPLE: (Pr) Milk production - Medium

2. Beef cattle:

3. Swine:

4. Sheep:

Lesson 1: Importance of Genetics in Agriculture Date__________________

BEEF HERD SELECTION

Compare the following bulls using their production records and EPDs. Determine which animal you would select for the herd. The bull would be used to breed 20 yearling heifers. In paragraph form, support your selection by writing the reasons you picked that animal.

Bull #1	Actual data	EPDs	ACC
(M) Birth weight	75	+1	.91
(Pr) Weaning weight	690	+32	.90
(Pr) Yearling weight	1190	+47	.90
(Ph) Frame score	6.5		
(Ph) Hip height	52"		
(Pr) Ave. daily gain	3.0		

Bull #2	Actual data	EPDs	ACC
(M) Birth weight	83	+8	.51
(Pr) Weaning weight	710	+36	.42
(Pr) Yearling weight	1270	+61	.42
(Ph) Frame score	7.5		
(Ph) Hip height	54"		
(Pr) Ave. daily gain	3.5		

1. Which bull would be best to improve weaning weight? __________ Why?

UNIT II - GENETICS

Lesson 2: Basic Building Blocks of Genetics

Objective: The student will be able to describe and identify basic building blocks of animal genetics.

Study Questions

1. **How do cells function?**
2. **How does DNA affect genetics in livestock?**
3. **How does RNA affect genetics in livestock?**

References

1. Student Reference

UNIT II - GENETICS

Lesson 2: Basic Building Blocks of Genetics

TEACHING PROCEDURES

A. Introduction

B. Motivation

How does hair grow back? How do fingernails grow? Why do wounds heal? What starts the disease, sickle cell? All these questions deal with the basic building blocks of all living things--*cells!* With proper nutrition and health, cells reproduce through division to produce hair, fingernails, and new tissue. The sickle cell disease occurs when a specific amino acid cannot be produced. If that amino acid cannot be produced, the body slowly deteriorates. Encourage discussion on cell functions, parts, and differences.

C. Assignment

Have the class draw an animal cell by including the organelles and parts that make up a cell. This suggested exercise should be done before or during the discussion on cell parts.

D. Supervised study

E. Discussion

1. Discuss how the function and structure of cells apply to livestock genetics.

How do cells function?

a) Definition: Cells are the basic, microscopic units of structure and function of all living things. Cells reproduce through division.

b) Parts of the cell
   1) Organelles - In every cell, the smaller structures are called organelles ("little organs"). The organelles determine the function of the cell.
   2) Plasma membrane - The thin layer surrounding all cells is called plasma membrane. This active part of the cell controls which molecules can enter or exit the cell.
   3) Phospholipid - The plasma membrane consists of two layers of molecules called phospholipids. Phospholipids are made up of a lipid and a phosphate group. Lipids are not soluble in water, but phosphates are. Phosphates sandwich the lipid layer in the plasma membrane. This allows molecules to enter or exit the plasma membrane, but not lipids.
   4) Cell nucleus - The nucleus is a spherical organelle that is located near the center of the cell. It controls the production of proteins in the cell.
      (a) Nuclear membrane - This separates the content of the nucleus from the rest of the cell. The nuclear membrane allows substances to exit and enter the nucleus.
      (b) Chromatin - The chromatin holds the necessary hereditary information about the cell.
      (c) Chromosomes - During cell reproduction, the chromatin becomes more apparent in long strands of hereditary material called chromosomes.

        - (d) Nucleolus - The nucleolus, the darker part of the chromatin, is involved in ribosome production.
    - 5) Cytoplasm - Cytoplasm is the gel-like substance that surrounds and suspends organelles within the cell.
    - 6) Mitochondria - The mitochondrion is the organelle containing enzymes that release energy from food during cellular respiration. The number of mitochondria depend on the function of the cell. An active muscle cell, such as one in the heart, contains more mitochondria than less active muscle cells because it requires more energy.
    - 7) Ribosomes - Ribosomes are tiny, round organelles that are involved in protein synthesis.
    - 8) Endoplasmic reticulum - Endoplasmic reticulum is made up of long strands of membrane, to which a majority of ribosomes are attached. These ribosomes synthesize proteins that are released from the cell for use by other cells. Unattached ribosomes in the cytoplasm synthesize proteins used by the cell itself. A rough endoplasmic reticulum has ribosomes attached to it. A smooth endoplasmic reticulum lacks ribosomes and is not involved with protein synthesis, but adds structure to the cell.
    - 9) Golgi bodies - These flat, membrane-bound sacs prepare proteins for secretion from the cell. Golgi bodies aid in the release of proteins from the cell. *Vesicles* are tiny pieces of membrane pinched off the Golgi body that actually carry the protein to the plasma membrane.
    - 10) Vacuoles - Vacuoles are membrane-bordered, fluid-filled spaces within the cytoplasm. Vacuoles usually contain water used in the cell and provide structure for the cell.
    - 11) Lysosomes - Lysosomes are organelles that digest proteins. Enzymes present in lysosomes break down proteins and recycle the amino acids to make new proteins.
    - 12) Cytoskeleton - The cytoskeleton is the tiny internal support system found in cells. The cytoskeleton is made up of microtubules, which are tiny protein strands that provide support in the cell. The microtubules provide the cell with its shape, which limits the movement of organelles within the cell.
    - 13) Centrioles - Centrioles are organelles that contain bundles of microtubules which lie close to the nucleus. The centrioles play an important role in cell division. Centrioles exist in pairs and are composed of nine sets of microtubules.
- c) Types of cells
    - 1) Eukaryotes - Eukaryotes are cells that contains a membrane-bound nucleus. The eukaryote's chromatin is held within a well-defined nucleus. (Not all organisms contain a nucleus.)
    - 2) Prokaryotes - Prokaryotes are cells that do not have a membrane-bound nucleus. Bacteria are considered prokaryotes because the chromatin is stretched out within the cytoplasm, not held within the nucleus. Another distinction between eukaryotes and prokaryotes is that prokaryotes lack organelles such as mitochondria and Golgi bodies, which are also membrane-bound.
- d) Functions of cells
    - 1) Nutrition - ability of cells to manufacture their own food or obtain food from another environmental source
    - 2) Cellular respiration - process of changing the energy in food molecules into a usable form of energy
    - 3) Absorption - process of absorbing water, minerals, and other necessary elements from their environment
    - 4) Biosynthesis - process of synthesizing complex compounds from simpler compounds, e.g., changing proteins into amino acids

e) Differences between plant and animal cells
   1) Cell walls - Plant cells contain a cell wall that surrounds the plasma membrane. Animal cells possess only a plasma membrane.
   2) Chloroplasts - Plant cells contain chloroplast, which provides the green color.
   3) Chlorophyll - In plant cells, chlorophyll utilizes sunlight to manufacture food.
   4) Plastids - Plant cells contain plastids, which are organelles capable of storing food for the cell.
   5) Chromoplasts - Plant cells contain chromoplasts, which give flowers and fruits their color (e.g., red tomatoes and yellow apples).

2. Explain DNA.

How does DNA affect genetics in livestock?

TABLE 2.1 - DNA strand

S	------	GC	------	S
P				P
S	------	CG	------	S
P				P
S	------	AT	------	S
P				P
S	------	TA	------	S
P				P
S	------	GC	------	S
P				P
S	------	CG	------	S
P				P
S	------	AT	------	S
P				P
S	------	TA	------	S

P-Phosphate
S-Deoxyribose sugar
A-Adenine
T-Thymine
G-Guanine
C-Cytosine

a) Definition: **Deoxyribonucleic acid** (DNA) is a nucleic acid molecule that controls the production of proteins. DNA is similar to a library in that it stores vital information about the cell. The DNA instructions are used repeatedly in cell division and protein synthesis.
b) In eukaryotes, the DNA is stored in the chromosomes of the nucleus.
c) In prokaryotes, the DNA is stored in circular strands in the cytoplasm.
d) Structure of DNA
   1) DNA is composed of nucleotides. Through chemical analysis, it has been determined that nucleotides are made up of three parts: a phosphate group, a five-carbon sugar called deoxyribose, and a nitrogen base. The four types of nitrogen bases are:
      (a) Adenine
      (b) Guanine
      (c) Thymine
      (d) Cytosine
   2) The "base pairing rule for DNA" means that adenine is paired with thymine and guanine is paired with cytosine. These pairs are then attached to a phosphate and a deoxyribose sugar. These DNA strands are then twisted into a spiral, like a spiral staircase. This spiral twist is called double helix. Table 2.1 shows the structure of a DNA strand.
   3) A single DNA molecule can be millions of base pairs long. The order in which the bases are paired determines the DNA's ability to run and the function of the cell.
   4) Amino acids are formed by codons. Codons are three nitrogen bases attached together to form an amino acid. See Table 2.3 for a list of codons that make up the 20 most common amino acids.

TABLE 2.3 - The 20 Most Common Amino Acids

Essential amino acids	Non-essential amino acids
Arginine (TCT, TCC, GCA, GCG, GCT, GCC)	Alanine (CGA, CGG, CGT, CGC)
Histidine (GTA, GTG)	Asparagine (TTA, TTG)
Isoleucine (TAA, TAG, TAT)	Aspartic acid (CTA, CTG)
Leucine (AAT, AAC, GAA, GAG, GAT, GAC)	Cysteine (ACA, ACG)
Lysine (TTT, TTC)	Glutamic acid (CTT, CTC)
Methionine (TAC)	Glutamine (GTT, GTC)
Phenylalanine (AAA, AAG)	Glycine (CCA, CCG, CCT, CCC)
Threonine (TGA, TGG, TGT, TGC)	Proline (GGA, GGG, GGT, GGC)
Tryptophan (ACC)	Serine (AGA, AGG, AGT, AGC, TCA, TCG)
Valine (CAA, CAG, CAT)	Tyrosine (ATA, ATG)

5) Any one of the codon triplets could make up the amino acid. It does not take all of the triplets to make the amino acid. Several codons represent the same amino acid. Since they have the same meaning, the redundant codons are like synonyms of words.

3. Explain RNA.

How does RNA affect genetics in livestock?

Table 2.2 - RNA strand
R--G P R--A P R--U P R--C P R--G P R--A P R--U P R--C
R-Ribose sugar P-Phosphate G-Guanine A-Adenine U-Uracil C-Cytosine

a) Definition: Ribonucleic acids (RNA) are much shorter than DNA. RNA carries messages, transforms proteins, and aids in ribosome formation.

b) Types of RNA (m-RNA, t-RNA, r-RNA)

  1) In eukaryotes, DNA never leaves the nucleus, so RNA carries the messages from nucleic DNA to ribosomes. This RNA is called messenger RNA or m-RNA.

    (a) Transcription - Transcription is the process of copying the DNA code to RNA strands. Transfer RNA (or t-RNA) get all the necessary amino acids and line them up in the right order to build a specific protein. The cytoplasm contains all the amino acids necessary for building a specific protein. The t-RNA gathers the proper amino acids and brings them to the m-RNA.

    (b) Translation - Translation is the process of assembling chains of amino acids according to the directions carried by m-RNA and translating the message into a particular protein.

  2) The formation of the structure of ribosomes is called ribosomal RNA or r-RNA. These r-RNA are made in the nucleolus.

c) Differences between DNA and RNA

  1) RNA nucleotides contain the sugar, ribose, instead of deoxyribose.

  2) RNA contains the nitrogen base, uracil, instead of thymine. Like thymine, uracil forms a complementary pair with adenine.

3) RNA usually has only one strand instead of DNA's two. RNA does not form a helix. See Table 2.2.

F. Other activities

Have students research a current genetics topic based on topics covered in this lesson.

G. Conclusion

Cells, DNA and RNA are the starting points for all genetic occurrences in livestock. That is why it is so important to comprehend the functions and structures in cells.

H. Competency

Describe the basic building blocks of genetics.

Related Missouri Core Competencies and Key Skills

10B-1: Describe the functions of the organelles of a cell (cell wall, cell membrane, nucleus, ribosome, mitochondrion, chloroplastid, vacuole).
10B-3: Describe the structure and function of DNA.
10D-8: Compare and contrast photosynthesis and cellular respiration.

I. Answers to Evaluation

1. c
2. k
3. d
4. j
5. g
6. i
7. e
8. b
9. f
10. h
11. Eukaryotes
12. Vesicles
13. Organelles
14. Prokaryotes
15. DNA
16. Codons
17. Biosynthesis
18. Adenine
19. Cytosine
20. RNA
21. Two of the following:
    a) RNA nucleotides contain the sugar ribose instead of deoxyribose.
    b) RNA contains uracil instead of thymine.
    c) RNA has one strand instead of two and forms no helix.
22. Amino acids are formed by codons. Codons are three nitrogen bases attached together to form an amino acid.

UNIT II - GENETICS Name________________

Lesson 2: Basic Building Blocks of Genetics Date________________

EVALUATION

Match the word on the left with the definition on the right.

1. ____ Cell nucleus
2. ____ Centrioles
3. ____ Cytoplasm
4. ____ Cytoskeleton
5. ____ Golgi bodies
6. ____ Lysosomes
7. ____ Mitochondria
8. ____ Plasma membrane
9. ____ Ribosomes
10. ____ Vacuoles

a. Long strands of membrane to which a majority of ribosomes are attached

b. Thin layer surrounding the cell which allows molecules to enter and exit the cell

c. Spherical organelle that controls protein production in the cell

d. Gel-like substance that suspends organelles in the cell

e. Organelle containing enzymes that release energy from food

f. Tiny, round organelles that are used to synthesize proteins

g. Flat, membrane-bound sacs that prepare proteins for secretion from the cell

h. Membrane-bound, fluid-filled spaces within the cytoplasm

i. Organelles that digest proteins

j. The tiny internal support system in cells

k. Organelles that contain bundles of microtubules, which aid in cell division

Fill in the blank with the best answer.

11. Cells that contain a membrane-bound nucleus are called ______________.

12. Pinched off Golgi bodies, the tiny pieces of membrane that carry proteins to the plasma membrane are called ______________.

13. Smaller membrane-bound structures that determines the function of the cell are called ______________.

14. Cells that do not have a membrane-bound nucleus are called ______________.

15. A nucleic acid that controls protein production and stores vital information about the cell is called ______________.

16. A set of three nitrogen bases that determine an amino acid is called ______________.

17. The cellular process of synthesizing complex compounds from simpler compounds is called ________________.

18. Thymine is always paired with ________________ in a DNA strand.

19. Guanine is always paired with ________________ in a DNA strand.

20. A nucleic acid that carries messages, transforms proteins, and aids in ribosomes formation is called ________________.

21. What are two of the three differences between DNA and RNA?

    a.

    b.

22. How are amino acids formed within the cell?

UNIT II - GENETICS

Lesson 3: Animal Cell Division

Objective: The student will be able to describe and understand the process of animal cell division.

Study Questions

1. **What are the functions of chromosomes?**
2. **How many chromosomes are present in common production livestock?**
3. **What is mitosis?**
4. **What is meiosis?**

References

1. Student Reference
2. Transparency Masters

TM 3.1:	Phases of Mitosis
TM 3.2:	Stages of Meiosis

UNIT II - GENETICS

Lesson 3: Animal Cell Division

TEACHING PROCEDURES

A. Review

Review the previous lesson.

B. Motivation

Do all animals possess the same number of chromosomes? If not, why? Normally, animals of the same species possess the same number of chromosomes. The difference among species is that some animals carry more (or fewer) hereditary characteristics, so in turn, they need more (or fewer) chromosomes to carry these hereditary characteristics.

C. Assignment

D. Supervised study

E. Discussion

1. Have the students discuss how genetics are passed from the parents to their offspring. Ask the students how the genes are carried and arranged in the animal's cells.

   What are the functions of chromosomes?

   a) Inside the nucleus of the cell, there are rod-shaped bodies called chromosomes. Chromosomes are composed of minute parts called genes. Genes determine the hereditary characteristics of animals and are transmitted to the offspring from the parents.
   b) Chromosomes are diploid in number (exist in pairs) in all body cells, except sperm and egg cells. One chromosome of each pair comes from the father and one pair comes from the mother.
   c) The two chromosomes within the pair are called homologous chromosomes, meaning alike or equal.
   d) Chromosomes contain millions of genes. It is because of the large number of genes and possible combinations of genes that very few animals are exactly alike.

2. Ask the students if they think the number of chromosomes is the same in all animals.

   How many chromosomes are present in common production livestock?

   a) Animals of the same species have the same number of homologous chromosomes.
   b) The numbers of chromosomes found in the body cells of some domestic animals are shown in the following table.

TABLE 3.1 - Characteristic Numbers of Chromosomes in Selected Animals

ANIMAL	CHROMOSOME NUMBER (2n)	ANIMAL	CHROMOSOME NUMBER (2n)
Horse	64	Cattle	60
Human	46	Mule	63
Dog	78	Swine	38
Domestic cat	38	Sheep	54
Chicken	78	Goats	60

3. How are the genetic traits passed on from parental cells to offspring cells? Use TM 3.1 to illustrate the stages of mitosis.

What is mitosis?

a) All cells increase in number by cell division. Mitosis refers to the type of cell division in which body cells divide and form two new cells, each containing the complete set (or diploid number) of chromosomes found in the parent cell.

b) The process of mitosis consists of several stages.
  1) Prophase
    (a) Chromosomes shorten and thicken.
    (b) Each chromosome divides into a strand of two identical chromatids connected by a centromere.
    (c) The nuclear membrane disappears, and the centromeres of chromosomes attach to structures called spindle fibers, which are fibers sent out from the centromeres when they divide.
    (d) Located outside the nucleus, the centriole cell, divides and begins moving to opposite sides or poles of the cell.
  2) In the metaphase, chromosome centromeres align the equatorial plane of the spindle fibers at the cell's center (Refer to Figure 3.1) with the spindle fibers radiating to the centrioles at opposite ends of the cell.
  3) Anaphase
    (a) Chromosomes are ready to divide into the two chromatids, which will become the chromosomes of the new cell.
    (b) The centromeres of each chromosome divide in half, as do the chromosomes themselves.
    (c) The chromatids become the new chromosomes and are pulled to the centrioles at opposite ends of the cell.
  4) Telophase
    (a) The nuclear membrane of the two cells is formed.
    (b) The cytoplasm of the original cell divides, forming two new cells containing the same number of chromosomes as the mother cell.
  5) Interphase is the time that elapses before another prophase begins.

4. How is the sex of offspring determined at the time of fertilization? Use TM 3.2 to explain meiosis stages and to compare mitosis with meiosis.

What is meiosis?

a) The type of cell division that forms gametes (sex cells) is similar to mitosis in some ways and different in others.

b) Meiosis involves a first and second cell division.

c) Meiosis is called oogenesis in the female and spermatogenesis in the male. Each of these types of reproductive cells contains the haploid number of chromosomes. Thus, each contains genetic information that can be passed to the next generation. If meiosis did not occur, the life cycle could not continue.

d) First meiotic division
  1) Prophase
    (a) Homologous chromosomes pair up, giving the appearance of four chromatids side by side.
    (b) These homologous chromosomes can exchange parts or cross over, resulting in chromosomes that are different from either of the parent chromosomes.
  2) In metaphase, the chromosome pairs align themselves at the equator of the spindle fibers.
  3) Anaphase
    (a) Each pair of chromosomes separates into two dyads, consisting of a pair of chromatids connected by a centromere.
    (b) Each chromosome itself does not divide as in mitosis.
  4) Telophase
    (a) Nuclear membranes form.
    (b) Cytoplasm divides and the resulting new cells contain only one chromosome of each original pair. This is why meiosis is called reduction division.
  5) Gametes developed by meiosis are essential to the maintenance of the embryo's diploid number of chromosomes. In fertilization, the ova and sperm join, each of which is haploid in chromosome number.

e) In the second meiotic division, each nucleus contains only one of each chromosome (haploid). The cell goes through the same stages as in mitosis.
  1) Each chromosome, consisting of the two chromatids, divides in half and becomes a new chromosome in the gamete.
  2) However, because of the reduced division in the first stage of meiosis, each new cell has only one homologous chromosome. Each resulting gamete contains only one-half of the number of chromosomes present in the parent cell.

F. Other activities

Have students write down the hereditary characteristics carried by chromosomes for different species, such as cattle, humans, swine, etc. By compiling the results you can determine the differences in the number of chromosomes for each species.

G. Conclusion

An animal's body is made up of millions of cells. Animals grow by cell division. The cell nucleus contains chromosomes, which are found in pairs. One chromosome of the pair comes from the father and one comes from the mother. Ordinary cell division is called mitosis; each cell is exactly like the old cell. The reproductive cells are called gametes. Gametes divide by the process of meiosis.

H. Competency

Describe animal cell division.

Related Missouri Core Competencies and Key Skills

10A-2:	Distinguish between mitosis and meiosis.
10B-1:	Describe the functions of the organelles of a cell (cell wall, cell membrane, nucleus, ribosome, mitochondrion, chloroplastid, vacuole).

I. Answers to Evaluation

1. a. Prophase
   b. Metaphase
   c. Anaphase
   d. Telophase
   e. Interphase

2. Meiosis involves a first and second cell division. Meiosis is called oogenesis in the female and spermatogenesis in the male. Each of these types of reproductive cells contains the haploid number of chromosomes.

3. Cattle: 60
   Swine: 38
   Sheep: 54
   Horses: 64

4. c
5. a
6. c
7. a

UNIT II - GENETICS Name________________

Lesson 3: Animal Cell Division Date________________

EVALUATION

Complete the following short answer questions.

1. Name the five stages of mitosis.

   a.

   b.

   c.

   d.

   e.

2. How is meiosis different from mitosis?

3. How many chromosomes do following animals have?

   Cattle: _____ Swine: ______

   Sheep: ______ Horses: _____

Circle the letter that corresponds to the best answer.

4. In body cells, chromosomes occurring in pairs are called ____________ in number.
   - a. Haploid
   - b. Double
   - c. Diploid
   - d. Twins

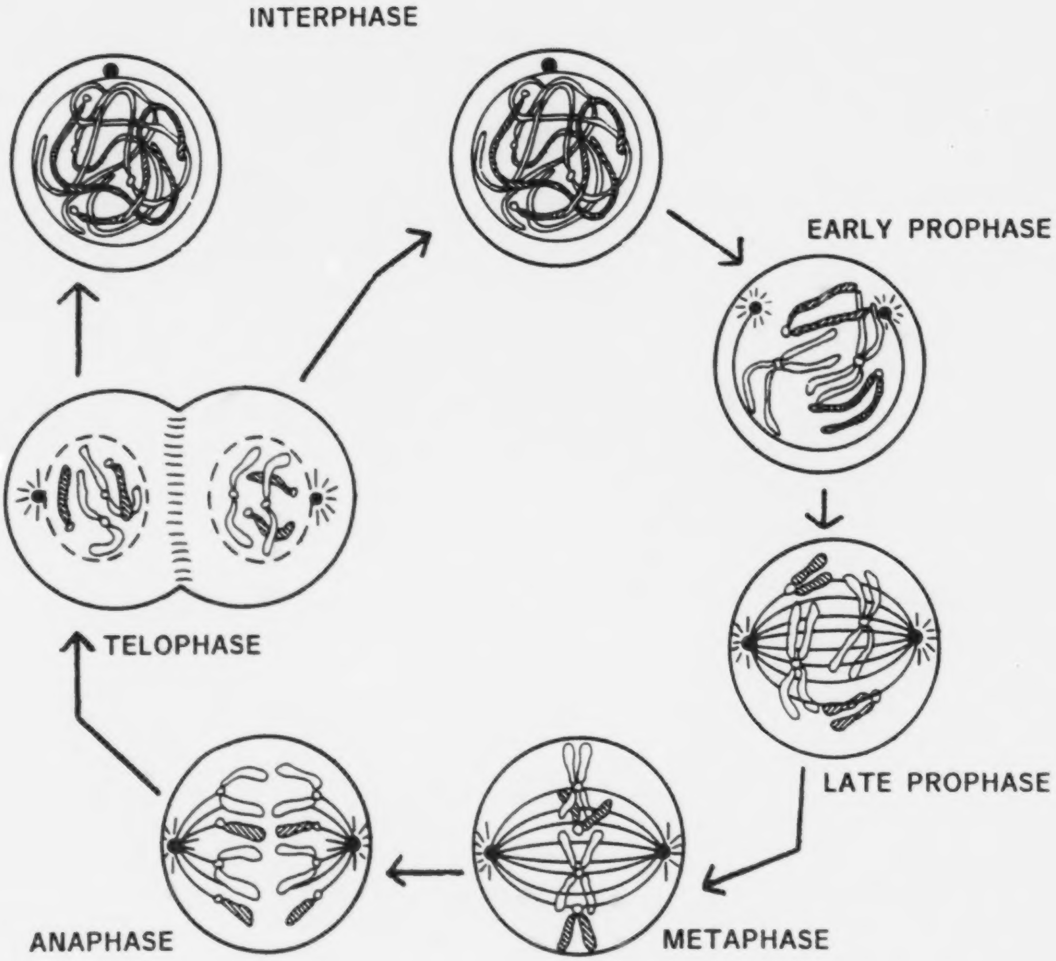
5. What are the minute parts of chromosomes called?
   - a. Genes
   - b. Chromatids
   - c. Spindles
   - d. Cytoplasm

6. What is meiosis in the female called?
   - a. Spermatogenesis
   - b. Telophase
   - c. Oogenesis
   - d. Ovaries

7. What is meiosis in the male called?

   a. Spermatogenesis
   b. Oogenesis
   c. Testosterone
   d. Anaphase

Phases of Mitosis

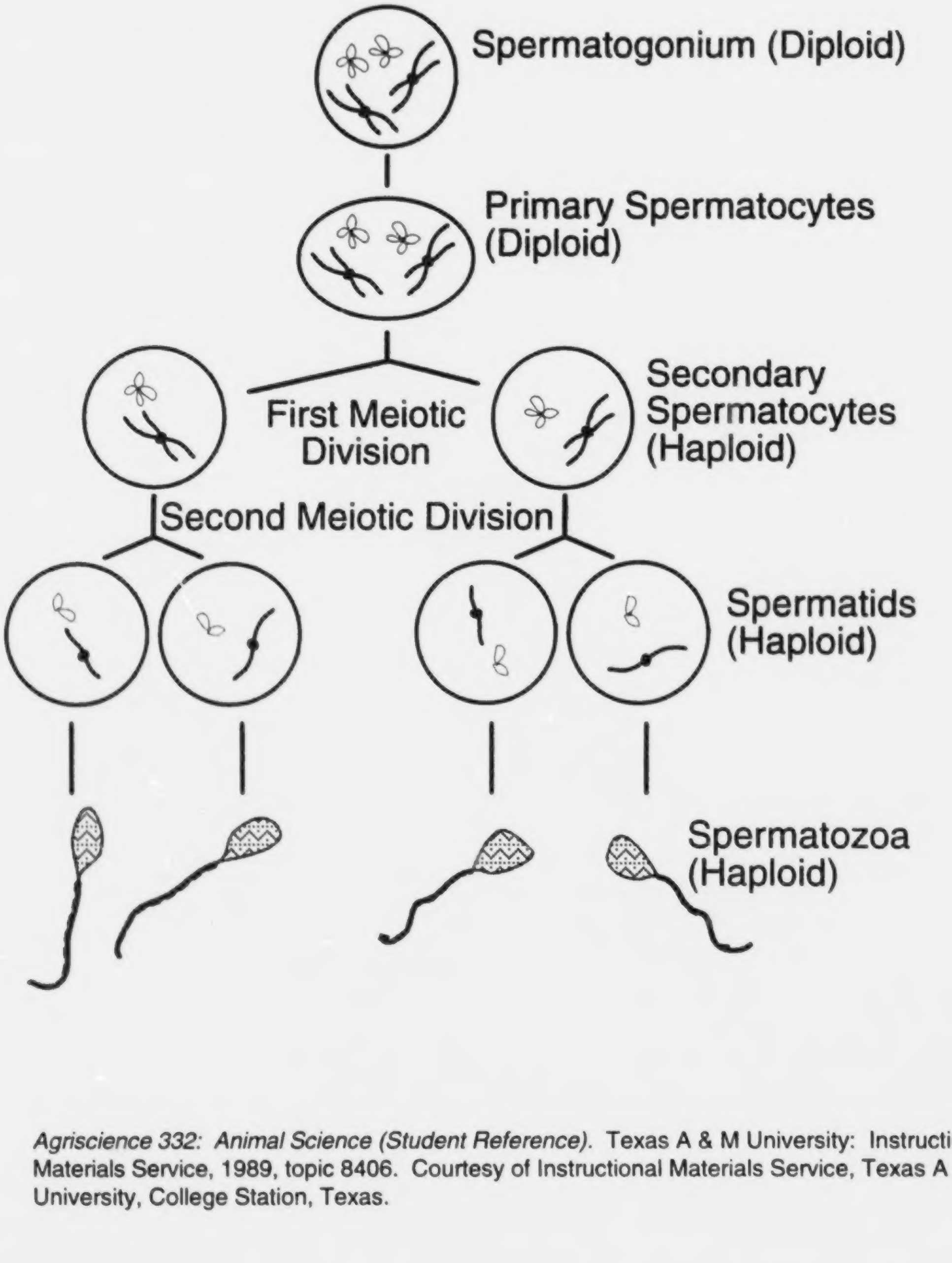

INTERPHASE
EARLY PROPHASE
LATE PROPHASE
METAPHASE
ANAPHASE
TELOPHASE

Credit: *Agriscience 332: Animal Science (Student Reference)*. Texas A & M University: Instructional Materials Service, 1989, topic 8406. Courtesy of Instructional Materials Service, Texas A & M University, College Station, Texas.

TM 3.2

Stages of Meiosis

SPERMATOGENESIS


Spermatogonium (Diploid)
Primary Spermatocytes (Diploid)
First Meiotic Division
Secondary Spermatocytes (Haploid)
Second Meiotic Division
Spermatids (Haploid)
Spermatozoa (Haploid)

Credit: *Agriscience 332: Animal Science (Student Reference).* Texas A & M University: Instructional Materials Service, 1989, topic 8406. Courtesy of Instructional Materials Service, Texas A & M University, College Station, Texas.

UNIT II - GENETICS

Lesson 4: Basic Principles of Genetics

Objective: The student will be able to explain and apply the basic principles of genetics.

Study Questions

1. **What role do genes and alleles play in genetics?**
2. **What is the difference between phenotype and genotype?**
3. **What are the differences between dominant and recessive genes?**
4. **What are the differences between homogenous and heterogenous traits?**
5. **What are the basic laws of genetics, and how do they influence the genetic makeup of animals?**

References

1. Student Reference
2. Transparency Master
    - a) TM 4.1: Punnett Square Examples

UNIT II - GENETICS

Lesson 4: Basic Principles of Genetics

TEACHING PROCEDURES

A. Review

1. Spend one class period reviewing the genetics unit of Agricultural Science I.

2. Review previous lesson.

B. Motivation

What are the differences between Angus and Polled Hereford cattle? What are the differences between Duroc and Hampshire hogs? How do you know if a cattle breed is going to be polled or horned? These traits are considered hereditary. They are controlled by the genetic makeup of the animal, which is largely controlled by genes.

C. Assignment

D. Supervised study

E. Discussion

1. Ask students where the word "genetics" comes from. Do they know how traits are passed from parent to offspring?

What role do genes and alleles play in genetics?

a) Genes are the basic units of heredity.
  1) The development of specific traits of animals is controlled by genes.
  2) They are part of the DNA molecule of chromosomes.
  3) Two genes, which are located on the same loci on each homologue, constitute a gene pair.
  4) Genes control traits in two ways.
    (a) Additive gene effects
      (1) These effects control a trait by the number of these genes that are present.
      (2) Each gene pair for this trait adds to its presence.
      (3) The effect of each pair is separate, but the effects of all the pairs for the trait add up to determine the trait's strength.
      (4) Traits with high heritability usually result from additive gene effects.
      EXAMPLE: Carcass quality in swine is a trait that results from additive gene effects.
    (b) Non-additive gene effects
      (1) This effect controls traits by how gene pairs act in different combinations with one another.
      (2) When gene pair combinations give good effects, the offspring will be better than either of its parents (heterosis or hybrid vigor).

b) Alleles
  1) Each gene pair contains two alleles.
  2) These two alleles interact to influence the character traits of an organism.

3) A species might contain different forms of the same gene (multiple alleles).
EXAMPLE: Flower colors, such as red, white, and yellow

2. Show students some genetic makeups (eg. TT, tt, Tt) and ask them what the animal would look like. Use TM 4.1 to illustrate Punnett square use.

What is the difference between phenotype and genotype?

a) A genotype is the actual configuration of genes in the animal's cells.
b) A phenotype describes the visible differences in the physical makeup of animals (color, weight, horned or polled, etc.).
c) Traits are phenotypic characteristics of animals. Traits are controlled by a pair of genes or several pairs of genes.
d) A checkerboard system (Punnett square) is used to predict the results of crossing animals with various kinds of genotypes.
    1) Male gametes are shown across the top of the checkerboard.
    2) Female gametes are shown along the left side of the checkerboard.
e) Phenotypic and genotypic ratios

3. Why are some traits exhibited by the animal and some are not? Why is one person tall and one person short, although the same gene controls height?

What is the difference between dominant and recessive genes?

a) Dominant
    1) The phenotypic expression of some genes is dominant.
    2) Genes are dominant when they cover or hide the expression of the allele, the corresponding gene on the other chromosome of the pair.
    3) Capital letters designate dominant genes (P for polled) when genotyping animals.
b) Recessive
    1) The allelic gene whose actions are covered up and not expressed is recessive.
    2) Lowercase letters designate recessive genes (p for horned) when genotyping animals.

TABLE 4.1 - Common Dominant and Recessive Traits

Dominant	**Recessive**
Black-colored Holstein	Red-colored Holstein
Polled cattle	Horned cattle
White-wooled sheep	Black-wooled sheep
Mule-footed swine	Normal-footed swine
Black-colored Angus	Red-colored Angus
White-faced Herefords	Self-faced Angus
Black-colored horse	Chestnut horse
Dutch-belt pattern	No belting pattern

4. Ask students how they think dominant and recessive traits affect the animal's genotype and the visible phenotypes that animal passes on.

What is the difference between homogenous and heterogenous traits?

a) When considering two alleles, there is a possibility of three genotypes (PP, pp or Pp), but only two phenotypes (polled or horned).

b) Homogenous (homozygous)
  1) An individual having two like genes for a trait (PP or pp) is pure or homozygous for that trait.
  2) The allele can be dominant or recessive for the particular trait it represents.
c) Heterogenous (heterozygous)
  1) An individual having two unlike genes for a trait (Pp) is heterozygous for that trait.
  2) Usually, the dominant allele decides the phenotypic characteristics, even if only one chromosome of the pair carries that information.

EXAMPLE: A Pp animal will be polled because P is the dominant trait.

5. Ask the students what influences how traits are passed from parent to offspring. Are there certain laws that cause one trait to appear?

What are the basic laws of genetics, and how do they influence the genetic makeup of animals?

a) Incomplete dominance
  1) A trait's phenotypic expression can also be the result of a lack of dominance.
  2) A typical example is the coat color in Shorthorn cattle.
    (a) The two allelic genes are R (red color) and W (white color).
    (b) If the genotype is RR, the animal is red.
    (c) If the genotype is WW, the animal is white.
    (d) However, if the genotype is RW, the animal will be roan or a mixture of red and white.
  3) The roan color is an example of incomplete dominance where neither the red nor the white gene is dominant over the other, so each trait is expressed in the offspring.
b) Epistasis
  1) Sometimes, a gene pair controls or affects the actions of another gene pair.
  2) One result of epistasis is the albino animal. This animal's hair, skin and eyes contain no pigment (coloring matter).
  3) Although the animal has genes for a typical body color, another gene pair prevents their normal expression. In this case, the gene pair that controls the function of the color genes is epistatic.
c) Sex-linked characteristics
  1) Some genes are carried only on the sex chromosomes.
  2) Because the X-chromosome is larger than the Y-chromosome, there are some traits on the X that do not pair up with genes on the Y.
  3) There are also certain portions of the Y that do not link to the X.
  4) The portions on the Y, therefore, are only transmitted from fathers to sons.
  5) Sex-linked traits are often recessive and are covered up in the female by dominant genes.

F. Conclusion

Much of the improvement in livestock results from using the principles of genetics. Genes control an animal's traits, and they are the basic units of heredity. Understanding the processes of gene action can assist in further genetic improvement in livestock.

G. Competency

Describe basic principles of genetics.

147

Related Missouri Core Competencies and Key Skills:

10C-1:	Predict the phenotypic and genotypic ratios of the offspring of a dihybrid cross using a Punnett square.
10C-4:	Associate the roles of genetic variation and natural selection with change in organisms over time.
10D-9:	Analyze the risks and benefits of genetic engineering to society.

H. Answers to Evaluation

1. Genes and alleles are chromosomes within the cell nucleus; they act as carriers for the genes.

2. a. Mutations - Genes can duplicate themselves. When a mistake occurs in duplication, a new gene, called a mutation, is born. Mutations can be either defective or beneficial and will result in a change in the code sent by the mRNA to the protein formation process.
   b. Incomplete dominance - The phenotypic expression of a trait can also be the result of a lack of dominance.

3. The genotype of an animal refers to the actual configuration of genes in the animal's cells. The phenotype refers to visible differences in the physical makeup of animals (color, weight, body structure, horned or polled, etc.).

4. Homogenous traits occur when an animal has two like genes for a trait (PP or pp), while heterogenous traits result from unlike genes.

5.

		Homozygous horned bull (pp)	
		p	p
Heterozygous polled heifer (Pp)	P	Pp	Pp
	p	pp	pp

The offspring will have a 50 percent chance of being heterozygous polled, and a 50 percent chance of being homozygous horned.

6.

		Horned bull (pp)	
		p	p
Polled cow (PP)	P	Pp	Pp
	P	Pp	Pp

		Roan bull (Rr)	
		R	r
Red cow (RR)	R	RR	Rr
	R	RR	Rr

Offspring will always be polled. Offspring will have a 50 percent chance of being red and a 50 percent chance of being roan colored.

UNIT II - GENETICS

Name_______________

Lesson 4: Basic Principles of Genetics

Date_______________

EVALUATION

Complete the following short answer questions.

1. What are the functions of genes and alleles?

2. List and describe two basic genetic laws.

   a.

   b.

3. Explain differences between phenotype and genotype.

4. Explain differences between heterogenous and homogenous.

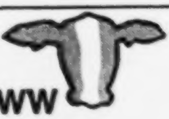
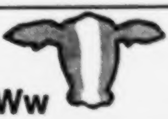
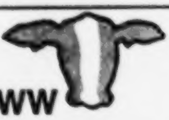
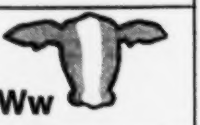
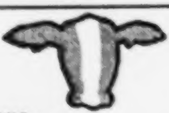
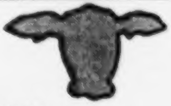
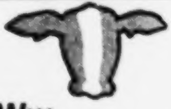
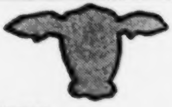
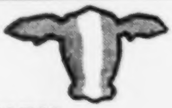
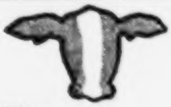
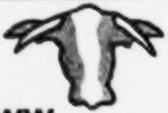
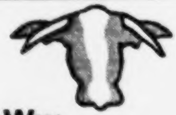
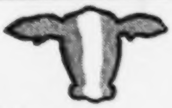
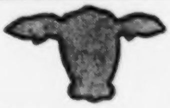
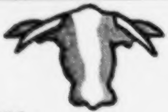
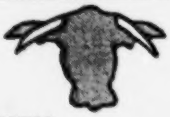
Determine the phenotypic and genotypic ratio of the following using the Punnett square. Show work.

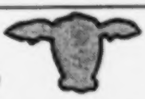
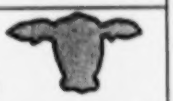
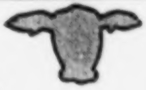
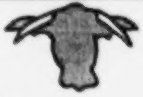
5. Homozygous horned bull (pp) X heterozygous polled heifer (Pp)

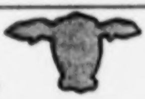
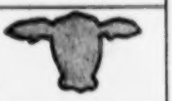
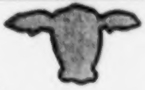
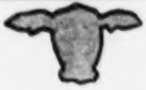
6. Horned roan bull (pp Rr) X polled red cow (PP RR)

TM 4.1

Punnett Square Examples

Male ♂ / Female ♀	PW	Pw	pW	pw
PW	PPWW 	PPWw 	PpWW 	PpWw 
Pw	PPWw 	PPww 	PpWw 	Ppww 
pW	PpWW 	PpWw 	ppWW 	ppWw 
pw	PpWw 	Ppww 	ppWw 	ppww 

Male ♂ / Female ♀	P	p
P	PP 	Pp 
p	Pp 	pp 

Male ♂ / Female ♀	P	P
p	Pp 	Pp 
p	Pp 	Pp 

Credit: *Agriscience 332H: Advanced Animal Science (Student Reference).* Texas A & M University: Instructional Materials Service, 1990, topic 8406. Courtesy of Instructional Materials Service, Texas A & M University, College Station, Texas.

UNIT II - GENETICS

Lesson 5: Tools for Genetic Improvement of Beef

Objective: The student will be able to describe the use of selection tools for genetic improvement of the beef herd.

Study Questions

1. **What factors are important in sire and female selection of beef?**
2. **What is meant by crossbreeding systems and hybrid vigor?**
3. **What are EPDs and how are they used?**

References

1. Student Reference
2. University of Missouri-Columbia Extension Division agricultural publication
    a) GO2032: Understanding and Using Sire Summaries

UNIT II - GENETICS

Lesson 5: Tools for Genetic Improvement of Beef

TEACHING PROCEDURES

A. Review

Review previous lesson on animal cell division and Unit II, Lesson 1.

B. Motivation

What are some factors to consider when establishing a beef herd? How are the best animals selected? Factors to consider when establishing a beef herd are: purebred or commercial, purebred or crossbred, price, adaptation, condition, age, longevity, health, herd size, and milking ability. Animal selection should be based on pedigree, individual performance and appearance, show-ring winnings, and performance testing.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss the methods used in selecting beef cattle sires and dams.

What factors are important in sire and female selection of beef?

a) Factors to consider when establishing a herd
  1) Purebred or commercial cattle
    (a) Purebred operators are a select few. They produce seed stock for other purebred producers and commercial producers.
    (b) Commercial operators produce the majority of cattle in America. Their goal is to convert land, grass, and crops into a monetary form through traditional cow-calf operations, backgrounding, and feedlots. Crossbreeding is the most widely used breeding system in commercial operations.
  2) The selection of a breed or cross
    (a) Purebred lines are usually chosen on personal preference or the breed with which the operator had the greatest success.
    (b) This a difficult decision for commercial operators because of the increasing number of crosses. If there are 10 breeds, there are be 45 single-cross choices and 360 possibilities in a three-way cross. Since there are more than 10 breeds (closer to 54 breeds), imagine all the possibilities.
  3) Milking ability strongly affects weaning weights, which are very important in the beef industry. The single most important factor in weaning weights is the ability of the mother to provide milk for her offspring. Remember, a lot of milk--a lot of calf, little milk--little calf.
  4) Uniformity
    (a) The essence of a purebred operation is a uniform herd. Having the same size and color are absolutely essential in the purebred industry.
    (b) In a commercial operation, uniformity is just as important. When it comes time to market the product, buyers like to see uniform groups of cattle from

the same operation. Uniformity in size and muscling is probably more important for a commercial operation.

5) Herd size does not determine herd quality. Quality cattle have been produced on a smaller scale. Cost is the one factor in deciding upon the herd size. The cost factor applies to both purebred and commercial operations.

6) Animal health is a factor in animal selection. The purebred industry requires a health certificate when an animal is sold. The commercial industry tests animals for diseases before the sale of an animal. Healthy beef are vital for the future of the industry.

7) Adaptation to environmental conditions in certain areas is not practical for certain breeds. This applies to both the purebred and commercial industries.

8) The condition of breeding stock is an important factor in selection of herd stock. Extremely thin or fat stock have lower reproduction rates.

9) Price
    (a) The price of purebred stock is largely determined by the operator's reputation and the quality of stock. Purebred stock costs more than market price because of extra costs in a purebred operation, the quality of stock, and genetic superiority.
    (b) In the commercial industry, it is seldom necessary to pay more than market price for females, but is beneficial to pay more for a sire to assure a quality animal.

10) Consider longevity and age. The longer a female can be productive reduces the cost of buying replacement animals. When deciding whether to buy younger or older stock, remember the number of years the animal has left to produce quality offspring.

b) Basis of selection in beef cattle

1) There are four bases of selection in beef cattle. Each selection method has its purpose, so it is up to the producer to emphasize one area of selection over the other.
    (a) Individuality and appearance
    (b) EPDs and performance records
    (c) Show-ring winnings
    (d) Pedigree

2) Selection based on individuality and appearance
    (a) The traditional score card lists different body parts of the animal. It lists parts such as flank, rump, loin area, structure, head, and neck. The score card places a numerical value on each part of the animal. A perfect score is 100 points. Breed associations have their own scorecards for their breed. This system is very valuable because appearance does not tell everything.
    (b) The functional scoring system divides the parts of the animal into areas: reproductive efficiency, muscling, size, freedom from waste, structural soundness, and breed type. The points given are 20, 20, 15, 15, 15, 15, respectively. These six areas are combined for a maximum of 100 points. Each area has economic importance.
        (1) Female reproductive efficiency - long body, leanness, sound udder structure, smooth muscles, functional udder, and feminine characteristics
        (2) Male reproductive efficiency - masculine, well muscled, well-developed genitalia, equal-sized testicles, and proper neck-to-scrotum length.
        (3) Muscling - Muscles smooth and round (not square), muscles bulge and move when walking, and loin bulges on both sides. Muscling applies more to bulls and steers than heifers.

153

(4) Size - Height at the hip and shoulder, adequate length of body, and leanness. Avoid early maturing bulls because they will not continue to grow.

(5) Freedom of waste - Trimness in both breeding and slaughter animals. Fat animals have lower reproductive rates and lower-quality carcasses. Avoid animals with loose hides.

(6) Structural soundness - Squarely set legs that are straight and true, toes and hocks squarely set, and equally sized toes. Avoid hocks and joints that appear swollen.

(7) Breed type - The animal should show signs of the breed, such as color; body markings, shape, and size; polled or horned; and shape of head.

3) In general, performance testing is the record keeping or data collecting as an animal matures. Performance testing is data collected on birth weight, weaning weight, yearling weight, rate of gain, feed efficiency, pasture gain, feedlot gain, carcass traits, and conformation score.

4) Selection based on pedigree
   (a) Pedigree selection is based on the ancestors' performance. The pedigree is used more extensively in the purebred industry than in commercial.
   (b) Economically important traits that can be inherited include fertility, birth weight, weaning weight, rate of gain, and carcass traits.

5) Selection can be based on show-ring winnings. However, animals that win in the show-ring usually have a high price tag. Show-ring winnings appeal to commercial producers, as well.

2. Why is crossbreeding important in beef cattle breeding systems?

What is meant by crossbreeding systems and hybrid vigor?

a) What is crossbreeding?
   1) Mating animals of different breeds is called crossbreeding.
   2) Crossbreeding is used for several reasons.
      (a) Increased productivity over purebred animals (hybrid vigor)
      (b) To produce animals with a combination of desirable traits not found in any one breed
      (c) Produces foundation stock for developing new breeds
   3) Advantages of crossbreeding
      (a) Crossbreeding introduces new and desired genes quickly or at a faster rate than selection within a breed. A good example of this is crossing a dairy breed with a beef breed. Beef females then have improved milking ability, which means bigger calves and more profit.
      (b) Hybrid vigor (heterosis) is the biological phenomenon that causes crossbred offspring to outproduce the average of their parents. Hybrid vigor occurs because the dominant genes in parents are usually more favorable than the recessive partner. When two separate gene pools are mixed together, the traits that were been lacking before become superior. (Example: dairy-beef cross)
      (c) Complementary traits are an the advantage a cross has over another cross or over a purebred. Here, two or more characteristics complement or combine with each other. This results in the maximum desired traits in a cross. Each breed is known for certain desirable characteristics. Matching them with another breed that does not possess those desired traits refers to complementary crossing.

4) Types of crossbreeding
   - (a) A two-breed cross is the mating of a purebred sire to a purebred female of another breed. Hybrid vigor will only appear in the offspring, which is a limitation of this cross. Another limitation is that the cross does not make use of a crossbred female.
   - (b) A two-breed backcross or crisscross is a system that involves mating a purebred sire of breed A with a female of breed B, then backcrossing the offspring to either breed A or breed B, resulting in a 1/4 to 3/4 breed. (Example: Mating a purebred Hereford sire and to a purebred Angus female, then mating the offspring to a purebred Angus sire, which results in a two-breed backcross or crisscross.)
   - (c) A three-breed rotational cross uses three breeds to make the cross. An example of this is mating a purebred Beefmaster sire to purebred Angus female and then mating the offspring to a purebred Hereford sire. The offspring is then mated back to a purebred Angus sire so that all three breeds had sired the offspring, results in a three-breed cross. Hybrid vigor will appear in all sets of offspring.
   - (d) A three-breed fixed or static cross (terminal cross) is a system where crossbred females (a two-breed cross) are mated to a third breed sire, results in three-breed fixed or static cross. In this system, all offspring are sold. When replacement females are needed, new females of a two-way cross are purchased. A limitation of this system is buying the same quality of crossbred replacement females.

3. Discuss how using them helps improve selection methods in beef cattle.

What are EPDs and how are they used?

a) What are EPDs?
   1) Expected Progeny Difference (EPDs) can be used to estimate how future progeny of the subject animal will compare to progeny of other animals within the breed. EPDs are designed to compare bulls based on estimated performance of the progeny, not to predict the performance on one or two progeny of a sire.
   2) A bull with a +50 lbs. yearling weight would be expected to sire calves 20 lbs. heavier, on the average, than calves out of a bull with +30 yearly weight EPD.

b) EPDs are used heavily in all phases of beef enterprises.

c) How can one tell if the EPD is accurate?
   1) ACC (accuracy) is the reliability measure of the EPD. An accuracy of 1.00 is of highest reliability. Accuracy is categorized as low, 0.00 to .5; medium, .51 to .75; and high .76 to 1.00. The possible change in pounds for each trait is more for lower accuracy. Reliability is increased as the number of progeny reported per sire increases.

      EXAMPLE: An ACC of .2 for weaning weight means that the EPD can change ±13.8. An accuracy of .9 in the same trait and breed means weaning weight would change ±1.7 lbs. for that sire.

   2) These examples of standards are set up by breed associations. In Table 5.1, Bull A has an ACC figure of .91, which means a calf sired by Bull A will have a weaning weight of 22.2-25.6 pounds heavier than Bull B. Another example of ACC figures is that a .2 ACC figure for birth weight represents ±3.1 lbs., and a .9 ACC figure represents ±0.4 lbs. This means a calf sired by Bull A will have a birth weight of 7.1-7.9 lbs. heavier than Bull B.

d) Table 5.1 shows an example of sire summary data for EPDs on four sires.

TABLE 5.1 - Sample Sire Summary Data

Sire	Birth weight		Weaning weight		Yearling weight		Milk	
	EPD	ACC	EPD	ACC	EPD	ACC	EPD	ACC
Bull A	+7.7	.93	+29.6	.91	+42.3	.78	-20.3	.85
Bull B	+0.2	.67	+5.7	.7	+29.1	.42	+4.9	.4
Bull C	+6.5	.89	+39.3	.85	+62.0	.72	+16.5	.72
Bull D	+0.5	.05	+10.2	.05	+31.1	.05	+8	.05

F. Other activities

1. Have students research different beef breeds. They can choose appropriate breeds for certain situations or contact associations for information, as the instructor prefers. (Letters should be approved by the instructor.)

   a) Missouri Beef Industry Council
   2015 Missouri Blvd.
   Jefferson City, MO 65109
   800/441-6242 or 573/636-6033

   b) Beef Improvement Federation
   ATTN: Ron Bolze
   Northwest Research Extension Center
   105 Experiment Farm Road
   Colby, KS 67701
   913/462-7575

2. Show the video segments, *Cutting Costs . . . Pocketing Profits* and *Profit by Using EPDs* (12 and 14 minutes, AG video 147), available from the Missouri Vocational Resource Center.

G. Conclusion

Application of correct selection methods and usage of EPDs are vital for beef producers to stay on the cutting edge of beef production.

H. Competency

Describe selection tools for genetic improvement of beef.

I. Answers to Evaluation

1. d
2. c
3. a
4. a
5. d
6. b, c, d, g (question worth 7 points)
7. a, c, d, e, f, h (question worth 8 points)
8. b, c, f, g (question worth 7 points)
9. a, d, e (question worth 8 points)

UNIT II - GENETICS Name______________

Lesson 5: Tools for Genetic Improvement of Beef Date______________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which cross involves mating a sire of breed A to a crossbred female of breed B and C, selling all offspring, and buying replacement females of the same cross?

   a. Two-breed cross
   b. Two-breed backcross or crisscross
   c. Three-breed rotational cross
   d. Three-breed fixed or static cross

2. Which cross mates a sire of breed A to a female of breed B, then mates the offspring to a sire of breed C before mating the offspring to a sire of breed B?

   a. Two-breed cross
   b. Two-breed backcross or crisscross
   c. Three-breed rotational cross
   d. Three-breed fixed or static cross

3. Which is true regarding EPDs?

   a. EPDs place a plus or minus value on a measurable trait.
   b. EPDs are used to measure progeny performance of purebred females.
   c. EPDs are used only in purebred operations.
   d. EPD stands for Expected Performance Difference.

4. Which animal part receives the more possible points in a functional scoring system?

   a. Reproductive efficiency
   b. Size
   c. Structural soundness
   d. Breed type

5. What is another name for hybrid vigor?

   a. Substitution
   b. Substraction
   c. Hetorosis
   d. Heterosis

Complete the following multiple answer questions.

6. Check the advantages of crossbreeding.

___ a. New and desired genes are slowly introduced.
___ b. Hybrid vigor
___ c. Offspring outproduce the average of their parents.
___ d. Complementary traits
___ e. Takes several generations to see desired traits appear.
___ f. Superior traits become less apparent.
___ g. New, desired genes are quickly introduced.

7. Check the factors to consider when establishing a beef herd.

___ a. Uniformity of herd
___ b. The larger the herd, the better the quality
___ c. Price of purchased stock
___ d. The selection of purebred or commercial operation
___ e. Breed of cattle
___ f. Matching type of cattle to environmental conditions
___ g. Selecting stock by condition instead of health
___ h. Type of breeding system to be used
___ i. Selecting stock for size instead of production levels
___ j. Selecting stock for price instead of longevity and age

8. Check all the characteristics of ACC (accuracy) figures.

___ a. It is a validity measure of the EPD.
___ b. It is a reliability measure of the EPD.
___ c. The higher the ACC figure, the more accurate the EPD
___ d. The lower the ACC figure, the more accurate the EPD
___ e. ACC figures are reported in ± numbers.
___ f. More progeny reported per sire results in a higher ACC figure.
___ g. More progeny reported per sire results in less change in the EPD figure.

9. Check all the characteristics of EPD figures.

___ a. EPD figures are reported in ± numbers.
___ b. EPD figures are valid measures of the ACC.
___ c. EPD figures are reliable measures of the ACC.
___ d. EPDs are an estimate of how future progeny of a subject animal will compare to progeny of another subject animal.
___ e. EPDs measure performance traits.
___ f. EPDs measure breed characteristics.
___ g. EPD figures are reported in percentages.
___ h. EPDs estimate how future progeny of a subject animal will compare to other progeny of the same subject animal.

UNIT II - GENETICS

Lesson 6: Selection Tools for Genetic Improvement of Dairy Cattle

Objective: The student will be able to use various selection tools and develop a plan to genetically improve dairy cattle.

Study Questions

1. **What factors are considered when selecting dairy cows?**
2. **How is sire evaluation data used in sire selection?**

References

1. Student Reference
2. Transparency Master
    a) TM 6.1: Dairy Cow Pedigree

UNIT II - GENETICS

Lesson 6: Selection Tools for Genetic Improvement of Dairy Cattle

TEACHING PROCEDURES

A. Review

Review Lesson 5.

B. Motivation

If you had two identical Holstein cows--same age, height, weight, udders, and physical traits--which one would you choose? Since the physical traits are the same, the choice would be very difficult. This is where genetics plays a role in dairy selection. If one cow produced 5 lbs. of milk more per day, she would pass on this hereditary trait to her offspring. This genetic selection also applies to butterfat percentage, birth weight, and multiple births.

C. Assignment

D. Supervised study

E. Discussion

1. Ask students to discuss factors they would use in selecting dairy cows. Have them justify why those points are important. Use TM 6.1 as an example of a pedigree.

What factors are considered when selecting dairy cows?

- a) Breed
  - 1) Availability of breeding stock of the desired type and quality
  - 2) The producer's markets for milk and butterfat
  - 3) Availability of forage crops and pastures, since larger, more rugged breeds require more roughage
  - 4) Climatic conditions
  - 5) Age of maturity
  - 6) A breed that is popular in the community, especially in terms of breeding stock sources and a market for surplus stock
  - 7) The size and vigor of newborn calves
- b) Individual dairy animals
  - 1) Type or physical appearance (linear classification)
    - (a) Form - Includes stature, strength, body depth, and angularity
    - (b) Rump - Includes angle, length, and width
    - (c) Legs and feet
    - (d) Udder - Includes fore attachment, rear height, rear width, support, and depth
    - (e) Teats
  - 2) Production records
    - (a) Dairy Herd Improvement Association (DHIA) records - Testing of cows is carried out by an approved tester who visits the dairy one day each month to weigh and sample milk, make butterfat tests, and calculate production and feed records. This information is sent to a data processing center for computation and summarization. The report contains individual cow records, such as daily milk weights, butterfat percent, concentrates fed,

reproductive status, value of milk produced, feed costs, and income-over-feed costs.

        (b) Owner-sampler records - The owner of the dairy collects data for the herd.
    3) Pedigrees
        (a) These show the summaries of official production records for the animal's ancestors back three generations.
        (b) Consideration should be given to the sire and dam, as they contribute 50 percent to the animal's makeup. Other ancestors contribute the other 50 percent.
    4) Health and vigor
        (a) General herd health can be determined by the calving record of the cows during the past year, the number of cows in production, the stages of production, and the amount of milk being produced.
        (b) It is desirable to purchase animals only from herds that have been vaccinated or tested for Bang's disease (brucellosis) and tested for tuberculosis and leptospirosis.
        (c) To minimize health problems, one should select animals from reputable breeders of disease-free herds.

2. Ask the students for factors to consider when selecting a sire for a dairy herd.

How is sire evaluation data used in sire selection?

a) Production of sires
    1) Planned mating of superior cows and bulls can produce superior sires for artificial insemination.
    2) Look for a cow that produces 4,000+ pounds of milk above her herd mates and for half-siblings producing 2,000-3000+ pounds above herd mates. Take note of cow families for desirable conformation type, longevity, good temperament, and reproductive efficiency.
    3) Mate the cow with a superior AI stud for high PD and repeatability. Semen collection from the offspring begins at 10-12 months of age. Then, in herds throughout the U.S., enough cows are mated with the young bull to obtain 50-100 production-tested daughters. The bull is placed "on the shelf" for 4-6 years until daughters mature and provide milk production records. Bulls with high PDs are widely used.
b) Sire selection
    1) Various indexes can be used to select a dairy sire.
        (a) Daughter average - selection based on the average production of the sire's daughters
        (b) Daughter-dam difference - considers the amount of increase or decrease in milk produced by a bull's daughters, as compared to their dams
        (c) Equal-parent index - based on the premise that the sire and dam contribute equally to the inherent milk-producing ability of the progeny. It is equal to twice the average production of the daughters, minus the average production of dams.
        (d) Daughter-contemporary herd difference - substitutes the herd average for the dam's average in the daughter-dam difference index. The sire index is equal to the daughter's average minus the herd average.
        (e) Daughter-contemporary herd index - substitutes the herd average for the dam's average production in the equal parent index. The sire index is equal to twice the average production of the daughters minus the herd average.

161

(f) Herd mate comparison - compares a sire's daughters with herd mates that freshen during the same season of the same year. This index removes most environmental differences, such as the season of calving.
(g) Adjusted herd mate average - adjusts each lactation of a sire's daughter for comparison with one another
(h) Predicted Transmitting Ability (PTA) - an estimate of the amount of superiority or inferiority an animal will transmit to its offspring. It is the most accurate measure available of an animal's genetic ability.

2) For herd improvement, a dairy producer should choose the following.
(a) Bulls with the highest Predicted Transmitting Ability (PTA)
(b) Bulls with high PTA values that also have high reliability values (narrow confidence interval)
(c) Several bulls with high PTA values when the reliability value is below 75 percent
(d) Bulls with a low percent of difficult births when breeding heifers

F. Other activities

1. Tour a local dairy. Ask the owner/manager to discuss the breeding plan and how replacement heifers and sires are chosen.

2. Have students research different dairy breeds. They can choose appropriate breeds for certain scenarios or contact associations for information, as the instructor prefers. (Letters should be approved by the instructor.)

a) Holstein Association USA, Inc.
Attention: Jason Devino
PO Box 808
Brattleboro, VT 05302
802/254-4551
b) Purebred Dairy Cattle Association
Attention: Jason Devino
PO Box 808
Brattleboro, VT 05302
802/254-4551
c) American Jersey Cattle Club
6486 E. Main
Reynoldsburg, OH 43068
614/861-3636

3. Show the video, *Cattle Breed Identification: Dairy* (21 minutes, AG video 220), available from the Missouri Vocational Resource Center.

4. Using pedigrees and sire PTA information, have students choose what sire they would select when given a specific dairy and that dairy's production goals.

G. Conclusion

When selecting for high-production dairy cattle, producers must evaluate the genetic potential for milk production, as well as visual selection for conformation. Production records help determine how long the cow will stay in the herd by providing information on good feet and legs, proper udder attachments, etc. Therefore, study the overall picture before making major decisions on replacement heifers/cows and sires.

H. Competency

Describe selection tools for genetic improvement of dairy herds.

Related Missouri Core Competencies and Key Skills:

10C-4: Associate the roles of genetic variation and natural selection with change in organisms over time.
10D-9: Analyze the risks and benefits of genetic engineering to society.

I. Answers to Evaluation

1. c, d, f, h, I, j (question worth 10 points)
2. a, c, e, g (question worth 9 points)
3. a, c, d, f h (question worth 10 points)
4. a, e, f, g (question worth 10 points)
5. d, e (question worth 9 points)
6. b
7. b
8. b

UNIT II - NUTRITION

Name______________

Lesson 6: Selection Tools for Genetic Improvement of Dairy Cattle

Date______________

EVALUATION

Complete the following multiple answer questions.

1. Select proper udder characteristics, as evaluated on the unified score card.

___ a. Tissue is hard and firm to the touch.
___ b. Six evenly spaced teats
___ c. Teats are perpendicular to udder floor.
___ d. Fore udder attachment is long and curves smoothly into cow's underline.
___ e. An ill-defined cleft separates the udder's left and right sides.
___ f. Udder is evaluated by sections and then as a whole.
___ g. The four quadrants are unbalanced and ill-defined.
___ h. Prominent mammary vein
___ i. Evenly spaced, equally sized teats
___ j. Rear udder attachment extends high and wide.

2. As evaluated on the unified score card, check desirable leg and feet characteristics.

___ a. Soles of feet are level with the ground.
___ b. Front legs are narrowly spaced.
___ c. Leg bones are flat, strong, and smooth.
___ d. When viewed from the side, the hock is straight and perpendicular to the ground.
___ e. When viewed from the rear, legs are straight and far apart.
___ f. The animal should **not** walk when evaluating feet.
___ g. Legs fit squarely under the body.
___ h. Regular hoof fitting will help prevent feet and leg problems.
___ i. Leg bones are fine and brittle.
___ j. Correct legs and feet reduce the longevity of milk production.

3. Which records are contained in a DHIA report?

___ a. Daily milk weights
___ b. Roughages fed
___ c. Reproductive status
___ d. Butterfat percentage
___ e. Expense-over-feed cost
___ f. Value of milk produced
___ g. Breeding costs
___ h. Feed costs
___ i. Birth weights
___ j. Weaning weights

4. Select the indexes used in dairy sire selection.

___ a. Daughter average
___ b. Daughter-sire difference
___ c. Herd sire comparison
___ d. Unadjusted herd mate average
___ e. Daughter-contemporary herd index
___ f. Daughter-contemporary herd difference
___ g. Equal-parent index
___ h. Feed conversion index
___ i. Milk yield index
___ j. Sire-contemporary herd index

5. Which are wise choices for a dairy producer to make when selecting sires for herd improvement?

___ a. Choose bulls with average PTA values and high reliability values.
___ b. Choose bulls with high PTA values and low reliability values.
___ c. Use several bulls when sires have high PTA values and reliability values less than 90 percent.
___ d. Use bulls with low percentage of difficult births when breeding mature cows.
___ e. Choose a bull with a high PTA value and high reliability values.
___ f. Use several bulls when sires have high PTA values and reliability values less than 70 percent.
___ g. Use only bulls with a narrow confidence interval.
___ h. Do **not** choose bulls with high PTA values.
___ i. Use only bulls with a wide confidence interval.
___ j. Choose bulls with a high percentage of difficult births when breeding heifers.

Multiple Choice: For each question that follows, use the table below to choose the best answer. Write its letter in the space provided.

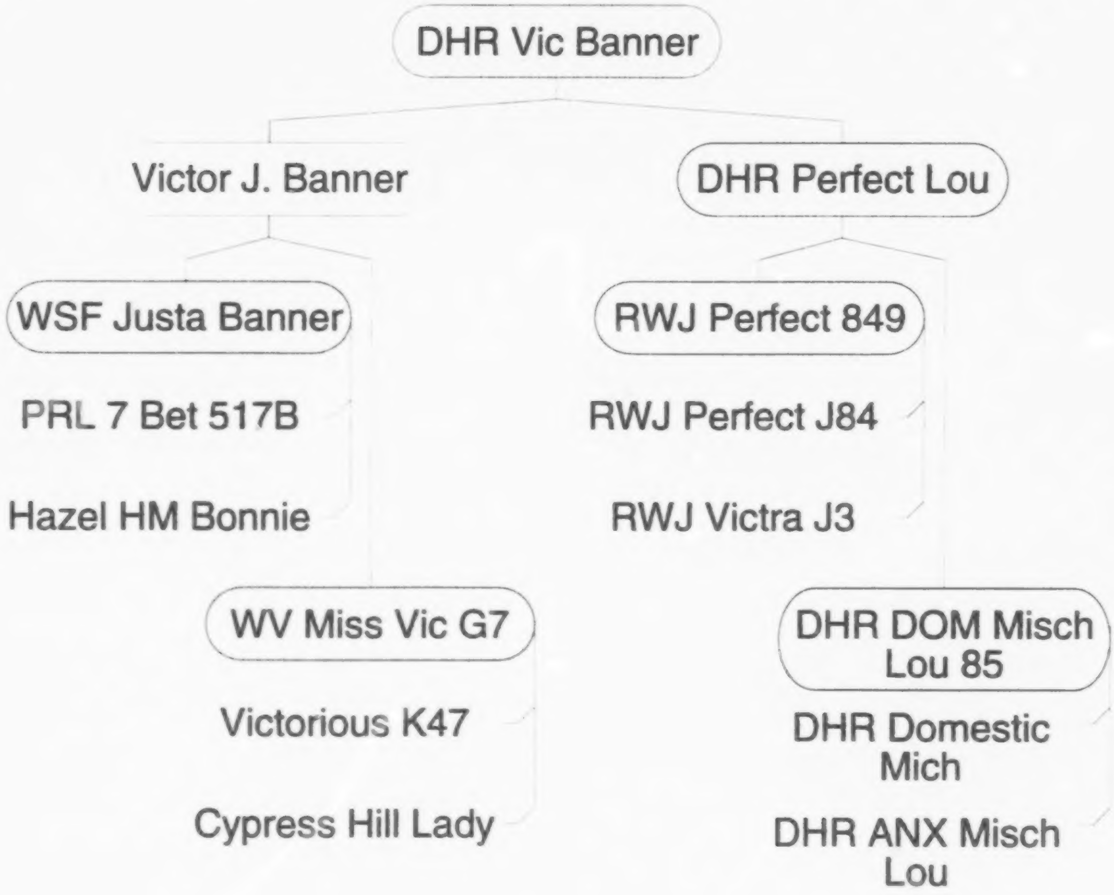
		Fat			Protein		
Name of bull	Milk	%	lbs.	$$	%	lbs.	$$
Bull A	+2,100	+.03	+42	+32	+.02	+39	+35
Bull B	+2,600	-.02	+61	+98	-.03	+59	+87
Bull C	+2,150	+.01	+37	+25	+.02	+40	+38

___ 6. Which bull would be the best choice if trying to improve offspring milk production?

___ 7. Which bull is best if trying to increase offspring production of pounds of fat?

___ 8. Which bull would be the best choice if trying to increase offspring production of pounds of protein?

Dairy Cow Pedigree


DHR Vic Banner
Victor J. Banner
DHR Perfect Lou
WSF Justa Banner
PRL 7 Bet 517B
Hazel HM Bonnie
WV Miss Vic G7
Victorious K47
Cypress Hill Lady
RWJ Perfect 849
RWJ Perfect J84
RWJ Victra J3
DHR DOM Misch Lou 85
DHR Domestic Mich
DHR ANX Misch Lou

UNIT II - GENETICS

Lesson 7: Tools for Genetic Improvement of Sheep

Objective: The student will be able to use selection tools for genetic improvement of the sheep flock.

Study Questions

1. **What factors are important in breeding stock selection?**
2. **Explain crossbreeding systems and hybrid vigor.**
3. **Why is performance data important in sheep selection?**

References

1. Student Reference
2. Activity Sheet

   AS 7.1: Analyzing Performance Data

UNIT II - GENETICS

Lesson 7: Tools for Genetic Improvement of Sheep

TEACHING PROCEDURES

A. Review

Review previous lesson on genetic improvement of dairy herds.

B. Motivation

What are some factors to consider when establishing a sheep flock? How is animal selection determined? Can a producer genetically improve a flock in one or two generations? Factors to consider when starting a flock are: selection of breed, native or western, uniformity, size of flock, health, age, soundness of udder, and price. Selection methods used in sheep are based on individuality or type, pedigree, show-ring winnings, and performance testing. Genetic improvement occurs through culling of undesirable animals, crossbreeding, and hybrid vigor.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss some factors to consider when establishing a sheep flock.

What factors are important in breeding stock selection?

a) Factors to consider when establishing a flock
    1) Experience should the main consideration when deciding whether to begin a purebred, crossbred, or grade flock. A purebred operation requires considerable experience with sheep and sheep selection, unless the price is comparable with crossbred or grade stock. A vast majority of the sheep operators elect to use high-grade ewes and a purebred ram.
    2) Breed selection is usually based on personal preference. Breed selection depends on what the producer wants from the herd--herding ability, long or fine wool, size, mutton or wool type, and adaption to environmental conditions.
    3) Native or western ewes
        (a) Native ewes are sheep produced outside the western range area. They are known for their mutton-type breeding. Native sheep are usually larger and cost more than western sheep.
        (b) Western ewes are usually smaller and less expensive than native sheep. Western sheep are more parasite resistant, which is vital in a range operation. Produced in the western ranges of the U.S., these sheep are usually a fine-wool by long-wool cross, which is essential for range animals.
    4) Uniformity is vital to a sheep producer because it is essential to have uniform market lambs and wool quality. Breeding stock should be selected by uniform size, conformation, and fleece quality.
    5) The ram is selected to match the female stock for ease of breeding and matching desirable traits.
    6) The size of a flock is usually decided by the experience of the operator, capital, amount of land, and the method of management. Larger operations are usually

commercial or grade flocks. The smaller flocks are usually the purebred operations. A beginner can gain valuable experience through a small flock without subjecting a larger flock to this inexperience.

7) The optimum time to begin a sheep operation is late summer when lambs are weaned and before ewes are bred.

8) All breeding stock should be thrifty, vigorous, and in very good condition. Stock should be capable of producing healthy, strong offspring.

9) When establishing a flock, age is an important factor. Older breeding stock is usually considered a bad investment. Begin the flock with yearling ewes to avoid getting someone else's problems. Also, replacement costs shouldn't appear for several years.

10) Udders should be soft and pliable. There should be four working teats of equal size and shape. Reject any ewes that are missing teats or have meaty or abnormal teats.

11) The price of sheep is like any other production operation. Premium prices will be paid for quality foundation stock. Price is usually based on the production of wool and the ability to produce quality lambs. Sheep prices are generally lower than other livestock, which should be considered when deciding on the type of livestock operation.

b) Selection bases of sheep

1) There are four criteria when selecting sheep for production and breeding stock. They are: type and individuality, pedigree, show-ring winnings, and production testing.

2) Selection based on type and individuality

(a) With fleece, the art of selecting sheep by observation is difficult. Production record use is extremely important when selecting stock for the flock.

(b) The "touch method" helps eliminate fleece-covering problems. The touch method helps determine economically important traits such as muscling, loin area, leg of lamb, and udder problems. It is used in culling ewes, eliminating light-fleece animals, and removing wool-blinded animals.

(c) Like cattle, there are score cards to use when evaluating sheep. The score card places numerical values on different parts of the animal, and the perfect score is 100 points.

3) Without a doubt, pedigree selection carries less weight in sheep than in any other livestock. It is rare to find a commercial producer contemplating a purchase because of pedigree. More emphasis of pedigree selection is put on stud rams than on ewes. Blood lines do carry some weight in the price of purebred stock, however.

4) Like other livestock, show-ring winnings usually dictate consumer wants and needs in sheep. Therefore, show-ring winners and their progeny are in great demand. Show-ring winners are usually a good investment if one is willing to pay a premium, but this usually done by purebred operators. Show-ring winners provide the type of animal that is productive and useful.

5) Selection basis on performance testing

(a) Like other livestock, selection based on production/performance testing is emphasized a great deal by producers and sheep buyers. Unlike other livestock, sheep have two products instead of one.

(b) Sheep production testing is divided into two areas--mutton and fleece production. Wool production is more prominent in the southwestern part of the U.S., and mutton production is more prominent in other parts of the country where feed grain is abundant.

(c) Production testing in sheep is a more accurate method of selection than any other method. Some of the economically important traits measured are multiple births, birth weight, weaning weight, rate of gain, fleece grade, and loin area.

2. Discuss the importance of crossbreeding in sheep production.

Explain crossbreeding systems and hybrid vigor.

a) Crossbreeding is the mating of two animals of different breeds.
b) Crossbreeding is used because of:
    1) Production of two products--mutton and wool
    2) The diverse conditions in which sheep are expected to produce
    3) The emphasis of hybrid vigor produced by crossbreeding
c) Advantages of crossbreeding
    1) Hybrid vigor or heterosis is the biological phenomenon that causes crossbred offspring to outproduce the average of their parents.
    2) Complementary traits are used to maximize desirable traits and minimizing undesirable traits. In sheep, rams and ewes do not contribute equally in offspring, so breeds of sheep are divided into ram breeds and ewe breeds.
    3) Crossbreeding introduces new and desired genes quickly or at a faster rate than selecting within a breed. Crossbreeding increases the yield of females compared to straight breeding in sheep.
d) Types of crossbreeding systems
    1) A two-breed cross mates a purebred ram of breed A to a purebred or high-grade ewe of breed B.
    2) A two-breed backcross or crisscross mates a purebred ram of breed A to a purebred or high-grade ewe of breed B, then mates the offspring back to a ram of either breed A or B.
    3) A three-breed cross mates a purebred ram of breed A to a purebred ewe of breed B, then mates the offspring to a purebred ram of breed C before mating the offspring to a purebred ram of breed B.

3. Explain how the National Sheep Improvement Program has become a resource for sheep producers. After the section on performance testing is covered, give students Activity Sheet 7.1 to evaluate their comprehension of performance testing.

Why is performance data important in sheep selection?

a) The National Sheep Improvement Program (NSIP) is a tool which helps producers improve the efficiency of lamb and wool production. The program was solely developed for genetic improvement for sheep flocks.
b) The NSIP is a computer-based program that provides output on the most accurate estimates of genetic merit for economically important traits. This output is based on individual sheep available in the U.S.
c) Input needed for NSIP
    1) Ewe data collected
        (a) Number of lambs born
        (b) Number of lambs reared
        (c) Weights at birth and at various ages (30, 60, 90, 120, 240, or 365 days) NOTE: Only three are needed.
        (d) Gains between designated ages
        (e) Ram days to lambing
        (f) Fleece weight as a yearling and annually thereafter
        (g) Fleece grade of the side and britch (hind quarters) (The micron count is optional.)

        - (h) Staple length
    - 2) Individual data collected
        - (a) Individual lamb identification number
        - (b) Sire identification number
        - (c) Dam identification number
        - (d) Type of birth
        - (e) Sex of lamb
        - (f) Type of rearing
        - (g) Date ewe was exposed to ram
        - (h) Date lamb was born
        - (i) Weights at birth and at various ages (30, 60, 90, 120, 240, 365 days) NOTE: Only three are needed.)
        - (j) Fleece weight
        - (k) Fleece grade of side and britch
        - (l) Micron count
        - (m) Staple length
        - (n) Other options are whether birth was assisted or unassisted, face scores, wrinkle scores, shoulder height, and carcass merit.
- d) Types of output from NSIP
    - 1) The three types of output provided by NSIP are: flock genetic evaluation summary, ewe lifetime production summary, and flock management summary.
    - 2) Flock genetic evaluation summary is the most important output provided by NSIP. It provides accurate estimates of genetic merit for every ewe, ram, and lamb in the flock. Measurements are provided by the inputs previously taken on ewes and individuals in the flock.
        - (a) Expected Progeny Difference (EPD) is also a part of flock genetic evaluation summary. EPDs are figured the same way as in cattle.
        - (b) Example: A ewe with a +3.2 for 90-day weight will produce lambs that are expected to be +3.2 lbs. heavier than an average lamb in the flock. An average lamb would have a 0 EPD rating. EPDs are also available for rams.
    - 3) Ewe lifetime production summary is an output provided for each individual ewe in the flock. It contains the ewe's pedigree, performance as a lamb, lambing intervals, lambs born and weaned, and the actual performance of every lamb to which she has given birth. This type of output is very useful for purebred producers to promote specific ewes and their progeny. This output also aids commercial producers in identifying truly outstanding ewes.
    - 4) Flock management summary provides a summary of the average performance of the flock for the present production year and the immediate previous year. This kind of output helps monitor of flock performance and identify management strengths and weaknesses.
        - (a) Distribution of lambing from the start of lambing season
        - (b) Age distribution of ewes
        - (c) Percent of single and multiple births for age group
        - (d) Reasons for culling
        - (e) Deaths

F. Other activities

1. Invite an Extension representative to come in with the NSIP computer program to show students the actual outputs a producer can receive.

2. Have students research different sheep breeds. They can choose appropriate breeds for certain scenarios or contact associations for information, as the instructor prefers. (Letters should be approved by the instructor.)

a) Missouri Goat Breeders Association
Rt. 1, Box 660
Humansville, MO 65674
417/754-8135

b) Missouri Sheep Producers, Inc.
HCR 3, Box 165
Edgar Springs, MO 65462
573/435-6508

G. Conclusion

It is critical for sheep producers and those in related occupations to use available resources in sheep selection and flock improvement. These resources can be beneficial in genetically improving any flock.

H. Competency

Describe selection tools for genetic improvement of sheep.

I. Answers to Evaluation

1. a
2. c
3. b
4. a
5. c
6. d

7. Any nine of the following:
   - Individual lamb identification number
   - Sire identification number
   - Dam identification number
   - Type of birth
   - Sex of lamb
   - Type of rearing
   - Date ewe was exposed to ram
   - Weights at birth, 30, 60, 90, 120, 240, and 365 days (only three are needed)
   - Fleece weight
   - Fleece grade of side and britch
   - Micron count
   - Staple length
   - Other options are: whether the birth was assisted or unassisted, face scores, wrinkle scores, shoulder height, and carcass merit

8. a) Flock genetic evaluation summary provides estimates of genetic merit for each individual sheep in a flock, which will help in culling and complementing ewe and ram genetically. EPDs will help in picking rams for flock.
   b) Ewe lifetime production summary provides each individual ewe's pedigree and performance records and their offspring performance records, which will help in culling and promoting certain ewes.
   c) Flock management summary provides data on flock performance for that year and the previous year to help evaluate strengths and weaknesses in flock.

J. Answers to Activity Sheet 7.1

1. Ram B would predictively produce a lamb 2.3 lbs. lighter than Ram C and a 1.2 lb. heavier lamb than Ram A. It also has a fairly high ACC figure of .83.

2. Ram A would predictively produce a lamb 2 lbs. heavier than Ram C and a 4.5 lb. heavier lamb than Ram B. It also has a fairly high ACC figure of .82.

3. Ram A would predictively produce a lamb 5.4 lbs. lighter than Ram B and a 12.9 lb. lighter lamb than Ram C. Its ACC figure ensures that these figures are fairly accurate.

4. Ram C is above average in two out of three categories. Most importantly, it will produce the heaviest lamb at the end of the year. It also possesses the highest ACC figures throughout.

UNIT II - GENETICS

Name_______________

Lesson 7: Tools for Genetic Improvement of Sheep

Date_______________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which is **false** regarding the NSIP?

   a. A flock evaluation summary gives data for the present and previous years.
   b. NSIP provides estimates for economically important traits.
   c. NSIP is available to every sheep producer throughout the U.S.
   d. NSIP is a computer program available at county extension offices.

2. In sheep, which is the most accurate method of selection?

   a. Individuality or type
   b. Show-ring winnings
   c. Performance testing
   d. Pedigree

3. When is the best time to begin a sheep flock?

   a. Mid-spring
   b. Late summer
   c. Mid-fall
   d. Late winter

4. Which describes native or western ewes?

   a. Known for their mutton-type breeding
   b. Usually smaller and less expensive
   c. Less likely to be infested with parasites
   d. Usually a fine-wool by long-wool cross

5. Why is crossbreeding frequently used in sheep production?

   a. Production of mutton vs. wool
   b. Helps feedlot sheep production
   c. Achieves hybrid vigor
   d. Improves the breed

6. Of the EPD scores below, which indicates a below-average ram?

   a. +3.4
   b. +2.2
   c. 0
   d. -1.8

Complete the following short answer questions.

7. List nine individual characteristics needed in data collection for NSIP.

    a.

    b.

    c.

    d.

    e.

    f.

    g.

    h.

    i.

8. Explain how the three outputs provided by NSIP can help a sheep producer genetically improve the flock.

    a. Flock genetic evaluation summary:

    b. Ewe lifetime production summary:

    c. Flock management summary:

Lesson 7: Tools for Genetic Improvement of Sheep

Name_______________

ANALYZING PERFORMANCE DATA

TABLE 7.1 - Sample Sire Summary Data

Sire	Birth weight		Weaning weight		Yearling weight	
	EPD	ACC	EPD	ACC	EPD	ACC
Ram A	-1.2	.75	+2.0	.82	-5.4	.90
Ram B	0	.83	-2.5	.87	0	.85
Ram C	+2.3	.91	0	.92	+7.5	.98

Complete the following short answer questions using the table above. Comment on ACC figures for each ram chosen, and assume the ram will be used with breeding aged ewes.

1. From the provided data, which ram would be considered average for birth weight? ______ Why?

2. From the provided data, which ram would be considered above average for weaning weight? _____ Why?

3. From the provided data, which ram would be considered a below-average ram for yearling weight? _____ Why?

4. From the provided data, which ram would you pick to sire a flock for all three categories? _____ Why?

UNIT II - GENETICS

Lesson 8: Selection Tools for Genetic Improvement of Swine

Objective: The student will be able to describe and choose selection tools to improve a swine operation genetically.

Study Questions

1. **What factors are evaluated in breeding stock selection?**
2. **Explain breeding systems used in swine.**
3. **How are other tools used in swine selection?**

References

1. Student Reference

UNIT II - GENETICS

Lesson 8: Selection Tools for Genetic Improvement of Swine

TEACHING PROCEDURES

A. Introduction

Review previous lesson and the swine unit from Agricultural Science I.

B. Motivation

Present the class with a situation in which they have been asked to choose a herd boar for a local swine producer. Give them photos, production records, goals of the producer, EPDs, and pedigrees. Ask the students to choose a herd boar from the situation given. Then, ask them if they needed to learn how to utilize the information effectively in order to make a more educated choice.

C. Assignment

D. Supervised study

E. Discussion

1. Ask the students to discuss what characteristics they feel would be important to consider when choosing breeding stock for a swine operation.

What factors are evaluated in breeding stock selection?

a) Breeds are selected based on seed stock or commercial operation goals. The most common U.S. breeds are:
    1) Duroc
    2) Yorkshire
    3) Hampshire
    4) Landrace
    5) Chester White
    6) Berkshire
    7) Spot
    8) Poland China

b) Composite lines are homogeneous lines of animals have been developed from crosses among two or more breeds and subsequently closed. These lines are managed much like a pure breed.

c) Performance testing is the practice of measuring the performance of the pigs in a herd for traits of economic importance.
    1) Traits that are economically important to the swine producer include:
        (a) Litter size (usually considered the most important trait)
        (b) Litter 21-day weight
        (c) Growth rate
        (d) Back-fat thickness
        (e) Loin eye area (along with back-fat thickness, helps determine slaughter hog price)
        (f) Feed efficiency
    2) Pigs must be identified using a marking system, ear tags or a standard pattern of ear notches. The performance of the pigs must be measured and recorded.

        3) The performance testing program can be as simple as recording litter size, the birth date of pigs, their date of slaughter and market weight.

    d) The next step up in complexity of performance testing involves weighing pigs and measuring back-fat thickness.
        1) Calculation is done for:
            (a) Litter weights at 21 days of age
            (b) Gains during the growing and finishing periods
            (c) Measurement of leanness
        2) Records must be adjusted to a common basis of comparison. Adjustment factors have been determined that help eliminate known sources of error.
        3) The National Swine Improvement Federation produces publications that contain adjustment factors.
        4) Computer software such as "PigChamp" and "PigTales" are an alternative to adjusting records by hand.
    e) At the highest level of performance testing, records are used to evaluate breeding values or expected progeny differences (EPD). EPDs are the current state-of-the-art for estimating an animal's genetic merit.

2. Ask the students what different types of swine production systems are used. Do all producers select similar types of swine for their herds?

Explain breeding systems used in swine.

    a) Crossbreeding produces approximately 95 percent of swine that are commercially slaughtered. There are two reasons for crossbreeding in commercial production.
        1) Frequently, heterosis (hybrid vigor) is favorably expressed by the crossbred animal.
            (a) Individual heterosis, expressed by the crossbred offspring, is measurable for traits such as growth rate and feed efficiency.
            (b) Maternal heterosis is expressed by crossbred sows, affecting progeny performance for traits such as 21-day litter weight.
            (c) Paternal heterosis is expressed by crossbred boars for traits such as sperm production and libido.
            (d) The amount of heterosis expressed in any cross is related to the common breed makeup of the parents and is described as a percentage. If the two parental breeds share no common breed makeup, heterosis is maximized at 100 percent.
        2) Another reason for using crossbreeding is to merge the desirable characteristics of two breeds into a single animal. The ability to combine specialized maternal or terminal characteristics of a breed is known as breed complementation.
    b) In general, rotational crossbreeding systems are easily managed and relatively inexpensive to operate.
        1) They suffer from less-than-maximum heterosis and no breed complementation.
        2) These systems are particularly well suited for medium- to small-sized operations.
    c) Terminal crossbreeding systems require purchase of replacement females or their production in a separate component of the herd, either of which is relatively expensive.
        1) This is offset by the maximization of breed complementation and heterosis (individual and maternal).
        2) These systems are well suited to large operations of 100+ sows.
    d) Rotaterminal crosses have some advantages of rotational and terminal systems.
        1) Replacement gilts are produced within a small component of the system. Breed complementation and individual heterosis are maximized in the terminal cross component.

        2) However, management of replacement female production and designing appropriate matings is complex in a rotaterminal crossbreeding system.

3. What types of records are kept on swine herds? Can these records be beneficial in selecting swine?

How are other tools use in swine selection?

a) The STAGES (Swine Testing and Genetic Evaluation System) program is a computer package that evaluates expected progeny differences for traits of economic importance in swine production.
    1) STAGES operates through breed association offices. Performance records are sent to the associations for processing.
    2) The STAGES program estimates the genetic merit of animals relative to other animals in the breed.

b) Independent culling level refers to a method in which animals are culled if they perform below expectation for any trait considered important. In most selection programs, two or more traits must be considered simultaneously when making selection decisions.

c) A selection index that includes weightings for various traits might be used. The appropriate weightings or multipliers have been determined for different conditions and are given in National Swine Improvement Federation materials; these should be available from a local extension specialist.

d) In marker-assisted selection, DNA is recognizable for many genes that have small influences on economically important traits.

e) Several physiological defects are occasionally observed in swine herds.
    1) Porcine stress syndrome (PSS) can result in pigs with a recessive gene at a particular location on both copies of a chromosome pair. PSS can be fatal to stressed pigs. Signs include labored breathing, shaking and a blotchy appearance on the skin. A DNA blood test is now available that can test whether an animal carries 0, 1 or 2 copies of the gene that results in PSS.
    2) Rectal prolapse happens when the rectum becomes loose from its supporting connective tissue and protrudes through the anus. Often, this condition is associated with estrogenic compounds in the feed, an inflammation of the lower gut, and excessive piling or coughing among pigs.
    3) Umbilical and scrotal hernias result when abdominal organs protrude through the umbilical ring.
    4) In newborn pigs, splayleg causes the rear legs extend outward to the side of the body and the pig is unable to stand properly. This condition frequently results from the sow's intake of moldy feed.
    5) Inverted nipples do not extend outward from the body. A poorly inherited genetic component is often involved in causing inverted nipples.

f) Genetics is usually the cause if a defect shows up in a particular sire's progeny across multiple litters, but not in progeny produced by other sires.

F. Other activities

1. Bring in breed association magazines so students can identify some of the genetic selection tools learned.

2. Set up a scenario so the students must select a herd boar for a local producer using production information. Bring in catalogs from boar test stations or boar studs to provide the students with a selection of boars from which to choose.

3. Have students research different swine breeds. They can choose appropriate breeds for certain scenarios or contact associations for information, as the instructor prefers. (Letters should be approved by the instructor.)

   a) National Pork Producers Association
      PO Box 10383
      Des Moines, IA 50306
      515/223-2600
   b) Missouri Swine Improvement Federation
      (Missouri Pork Producers Association)
      6235 Cunningham Drive, Rt. 11
      Columbia, MO 65202-9612
      573/445-8375

G. Conclusion

In this increasingly competitive age, it is important to utilize all selection tools available in the swine industry today. Careful research must be done to ensure that the best choice is made.

H. Competency

Describe selection tools for genetic improvement of swine.

Related Missouri Core Competencies and Key Skills

10C-4: Associate the roles of genetic variation and natural selection with change in organisms over time.
10D-9: Analyze the risks and benefits of genetic engineering to society.

I. Answers to Evaluation

1. Four of the following: litter size, litter 21-day weight, growth rate, back-fat thickness, loin eye area, feed efficiency

2. a. Heterosis or hybrid vigor
   b. Breed complementation

3. Three of the following: litter size, birth date of pigs, date(s) of slaughter, market weight

4. b
5. c
6. a
7. d
8. d
9. a

181

UNIT II - GENETICS Name______________

Lesson 8: Selection Tools for Date______ ________
Genetic Improvement of Swine

EVALUATION

Complete the following short answer questions.

1. List four traits of economic importance to the commercial swine producer.

    a.

    b.

    c.

    d.

2. List two reasons for using crossbreeding in commercial production.

    a.

    b.

3. List three simple components of production records.

    a.

    b.

    c.

Circle the letter that corresponds to the best answer.

a. Purebred
b. Rotational crossbreeding
c. Terminal crossbreeding
d. Rotaterminal crossbreeding

5. Which breeding system maximizes breed complementation and individual heterosis?

    a. Purebred
    b. Rotational crossbreeding
    c. Terminal crossbreeding
    d. None of the above

6. Which test identifies the presence of PSS?

    a. DNA
    b. Urine
    c. Skin
    d. Treadmill

7. Which group produces adjustment factors for production record comparisons?

   a. State veterinarian office
   b. Local extension office
   c. Purdue University
   d. National Swine Improvement Federation

8. STAGES estimates the genetic merit of animals relative to other __________ .

   a. Gilts and sows
   b. Boars and barrows
   c. Herd animals
   d. Animals in the breed

9. Which defect results in labored breathing, shaking, blotchy skin and frequently death?

   a. PSS
   b. Rectal prolapse
   c. Umbilical hernia
   d. Splayleg

UNIT III - REPRODUCTION

Lesson 1: Importance of Reproduction in Livestock

Objective: The student will be able to identify the importance of reproduction in livestock production.

Study Questions

1. **What careers are associated with livestock reproduction?**
2. **What are the economic factors associated with reproduction?**
3. **Identify parts and functions of the male reproductive system.**
4. **Identify parts and functions of the female reproductive system.**

References

1. Student Reference
2. Transparency Masters

TM 1.1: Comparison of Male Livestock
TM 1.2: Parts of a Cow's Reproductive Tract (Cut-Away View)

UNIT III - REPRODUCTION

Lesson 1: Importance of Reproduction in Livestock

TEACHING PROCEDURES

A. Review

Review previous unit on animal genetics.

B. Motivation

How does livestock reproduction affect the average consumer? For producers to receive the optimum price for their products, they must improve the herd's quality through reproduction and genetics. This improvement influences the quality of products available in the store. In turn, consumers influence livestock quality through their buying power.

C. Assignment

D. Supervised study

E. Discussion

1. Help students discuss careers associated with livestock reproduction and determine what education requirements are needed for these occupations.

   What careers are associated with livestock reproduction?

   a) A veterinarian deals with a wide spectrum of livestock reproduction activities. Some of these activities are: AI programs, semen collecting, pregnancy testing, embryo transfer, cloning, and assisting with births.
   b) Breed association representatives are constantly improving the breed through genetics and selective breeding.
   c) Breeding services, such as ABS, provide assistance such as access to semen for use in herds.
   d) Livestock scientists provide the latest research on livestock reproduction, such as genetic engineering.
   e) An Extension livestock specialist provides information to the producer on new and old methods of livestock breeding. These specialists are a resource used by livestock producers throughout the country.
   f) Livestock producers manage livestock reproduction for their income.
   g) A sales representative for livestock breeding products deals with the large supply of livestock products used in purebred and commercial breeding programs.

2. Ask students about inherited traits associated with livestock reproduction. These traits determine profit or loss in a livestock operation.

   What are the economic factors associated with reproduction?

   a) Beef cattle
      1) Calving interval - Cows which do not produce yearly calves are too costly for the producer to keep long.

    2) Birth weight is associated with calf survival rate; usually, larger calves are healthier and more vigorous.
    3) Weaning weights are a good indication of the mother's milking ability. Gains before weaning are cheaper to achieve than gains after weaning, resulting in increased profits for heavier weights.
    4) Maternal ability is important for calf survival and weaning weights.
    5) Daily rate of gain is significant in getting animals to market weight in a shorter period of time and is highly correlated with efficiency gain.
    6) Pasture gain becomes important when animals are raised on pasture. This is most apparent in backgrounding operations and cows on pastures.
    7) Efficiency of gain is important in rate of gain and conversion of feed into muscling.
    8) Final feedlot weight - More money is earned with animals that reach this weight at a faster rate. This weight is influenced by birth weight, weaning weight, and rate of gain.
    9) Conformation score becomes important in relation to animal longevity (life span) and appearance.
    10) Carcass traits become important in the quality and quantity of the edible final product. More profit results by producing more of a quality product.

b) Dairy cattle

    1) Milk production is the essence of a dairy operation. The more milk produced per animal, the more income that results for the producer.
    2) Percent fat is the icing on the cake. A higher percentage of butterfat in milk increases the price paid per pound of milk.
    3) Percent protein also determines the price per pound of milk. The higher the percentage of protein, the higher the price per pound of milk.
    4) Soluble nitrogen-free extracts help animals take advantage of more nutrients in feed and convert nutrients into usable products.
    5) Feedlot gain is not as important in dairy cattle as in beef cattle, but it is vital for dairy steers on a feedlot.
    6) Stature is significant to an animal's longevity and production, especially on hard surfaces.
    7) Legs and feet become very important for animals that are on concrete floors and lots.
    8) Udder support is vital to the length of time an animal can continue to produce milk.
    9) Milking speed - Time is money, especially in a dairy operation. The quicker a cow milks, the quicker milking proceeds, and the producer can move on to the next project.
    10) Birth weight is associated with calf survival rate and calving ease.
    11) Temperament becomes extremely important in the milking parlor. If an animal becomes excited and becomes hard to milk, that animal will have to be replaced or require more labor.
    12) Fertility is extremely important in milk production. The longer it takes a female to become fertile, the longer it takes for her to come into her milk cycle, which costs the producer.

c) Sheep

    1) Multiple births - The more lambs produced, the more money that can be made.
    2) Birth weights - Larger lambs generally mean more vigorous lambs and higher rates of gains.

    3) Weaning weights reflect that it is cheaper to add pounds from birth to weaning than after weaning.
    4) Rate of gain generally reflects milking ability of the mother and a faster growth rate, which means money in the pocket.
    5) Type score determines market value and the animal's ability to flourish in its environment.
    6) Finish or condition at weaning is important for market lambs. The better the condition and finish at weaning weight, the better the price.
    7) Wrinkles and skin folds determine the shearing ease and wool fiber uniformity.
    8) Face covering determines the ease of grazing for animals and increases labor costs for trimming. For example, sheep that are wool-blinded have facial wool that blocks their sight until it is trimmed.
    9) Fleece weight determines the price received for wool.
    10) Staple length influences the price received for wool because it measures the length of fibers.
    11) Carcass quality largely determines profit or loss for a farm flock producer.

d) Swine
    1) Litter size at birth - The more pigs that are produced, the more money that can be made.
    2) Litter size at weaning - Most of the pigs are lost between birth and weaning, so the more pigs saved, the more money that can be made.
    3) Birth weight - Heavier pigs have more vigor and an increased survival rate.
    4) Litter weight at weaning is very important to the feeder pig producer. Remember, it is cheaper to add pounds from birth to weaning than after weaning.
    5) Daily rate of gain from weaning to market weight is important to the market hog producer. The more efficient the hogs, the quicker they go to market.
    6) Feed efficiency - The better the conversion rate of feed to gain, the quicker the hogs go to market.
    7) Conformation score becomes very important for hogs in confinement that are on concrete surfaces.
    8) Carcass quality is very important for any swine producer. The higher the carcass quality, the more premium the price received for the product.

3. Parts of male reproductive system are also important economic traits for a livestock producer to consider when selecting sires. Show TM 1.1 to illustrate male reproductive parts and to discuss differences among classes of livestock.

Identify parts and functions of the male reproductive system.

a) Parts and functions of the male reproductive system.
    1) The scrotum is a heat-regulating structure that provides the proper temperature for sperm production. Sperm cannot be produced at normal body temperatures. The scrotum lowers the testes to cool them and contracts them when warmth is needed. For sperm production to occur, the testes must be 4-7 degrees Celsius lower than normal body temperature.
    2) Testes - All classes of male livestock have two testes. The testes produce sperm and secrete male sex hormones. The testes are made up of several thousand feet of very small, tangled tubes called seminiferous tubules.

3) Epididymis is an elongated body close to the testes. It consists of three parts--the head, the body, and the tail. The epididymis has four functions: to store, mature, transport, and concentrate the sperm. Sperm storage occurs in the tail of the epididymis. Sperm maturation is achieved through cell excretions. Sperm transportation is aided by water absorption.

4) The vas deferens transports sperm from the tail of the epididymis to the penis. The sperm pass by accessory glands like the seminal vesicles, prostate gland, and the Cowper's gland to produce the fluid called semen.

5) Seminal vesicles are located posteriorly under the prostate gland and empty into the urethra. Secretions produced by the seminal vesicles make up 50 percent of the fluid in semen. This yellow fluid consists of high concentrations of proteins, potassium, citric acid, fructose, and several enzymes. It usually has a pH of 5.7-6.2.

6) The prostate gland surrounds the urethra, and secretions pass into the urethra through small ducts along the urethra. Prostate secretions are similar to the secretions produced by the Cowper's gland. Prostate fluid usually has a pH of 7.5-8.2.

7) The Cowper's gland is located close to the rectum and above the urethra near its exit from the pelvic cavity. The Cowper's gland is about the size of a walnut and produces secretions to flush the urethra before mounting. The secretions are clear, watery, and sperm-free. This fluid has the same pH as in the prostate gland.

8) The urethra is a jointed canal used for both semen and urine. It runs throughout the length of the penis and carries urine or semen from the originating glands to the head of the penis.

9) The penis excretes urine or deposit semen into the reproductive tract of the female. Its length begins at the bladder and accessory sex glands and ends at the sheath.

10) The sigmoid flexure straightens, causing an erection of the penis, which aids copulation. Blood is pumped into the chambers of penis during sexual excitement, which causes the straightening of the sigmoid flexure.

11) Retractor muscles are used to retract the penis into the sheath. After copulation, the sigmoid flexure contracts and the retractor muscle retracts the penis into the sheath.

12) The sheath is the protective opening where the retracted penis is placed; it keep the penis in a fixed position in the non-erect state.

b) Differences in male reproductive tracts among classes of livestock

1) The ram's scrotum is shorter than the scrotum found on a bull. The ram's scrotum is also covered in wool. The ram's urethral opening extends out further than the head of the penis, which rotates and sprays semen during ejaculation.

2) The boar's scrotum is located just below the rectum, not hanging from the bottom of the animal as in some species. In the boar, the free part of the penis is shaped like a corkscrew. The boar has a preputial pouch located right above the opening to the sheath that is responsible for the strong sex odor in boars. This pouch contains a mixture of decomposing urine and macerated epithelial cells, which permeates the meat and gives it a bad taste. This is why most boar carcasses are not used for human consumption.

3) A stallion's scrotum is less pendulous than a bull's. In a relaxed state, the stallion's testes lie horizontally; in an excited state, the testes become almost vertical in nature. A stallion does not have a sigmoid flexure.

4. Functioning female reproductive parts are also considered important economic traits for consistent breeding ease and fertility. Show TM 1.2 to illustrate female reproductive parts.

   Identify parts and functions of the female reproductive system.

   a) The bladder stores urine. The urethral opening is the opening for the bladder.
   b) The vulva is the external opening of the urinary tract and the female reproductive tract.
   c) Ovaries are the structures that produce the egg or ovum.
   d) The infundibulum is a funnel-like structure that connects the ovary to the Fallopian tube.
   e) The Fallopian tube carries the egg or ovum from the ovary to the horn of the uterus. The ovary releases the ovum or egg 12 hours after the estrous cycle is complete. Fertilization occurs when the egg unites with the sperm in the upper third of the Fallopian tube.
   f) The uterus provides a pathway for sperm and is where the development of the fetus takes place. The fertilized egg empties from the Fallopian tube into the uterus, where it begins to develop.
   g) The cotyledon is an attachment point for connecting the placenta to the uterus.
   h) The cervix acts as a plug for the uterus when fertilization occurs. After fertilization, the cervix closes completely, sealing the uterine cavity and protecting the fetus from bacterial and foreign invasions. The cervix liquifies shortly before birth, allowing the fetus to be expelled from the uterus.
   i) The vagina is the female organ where the semen is deposited at copulation. Semen is deposited at different places, depending on the class of livestock and the copulation process. Semen can be deposited as far in as the uterus. Like the cervix, the vagina dilates during birth.
   j) The clitoris is the sensory organ that allows the penetration of the male penis. It is located in the vulva. This sensory organ allows copulation to occur and is stimulated during the estrous cycle.

F. Other activities

1. As a visual aid, consider using a reproductive tract from a slaughter house to point out parts of the female reproductive tract.

2. Show the video, *Beef Reproduction II* (43 minutes, AG video 7), available from the Missouri Vocational Resource Center.

G. Conclusion

A good knowledge of animal reproduction helps people in livestock production and related occupations understand the complexity of this process. Knowing economically important reproductive traits is a necessity for a person in this field.

H. Competency

Identify the importance of reproduction in livestock production.

Related Missouri Core Competencies and Key Skills

10B-4: Describe the structure and function of human reproductive organs.

I. Answers to Evaluation

1. Scrotum
2. Epididymis
3. Sigmoid flexure
4. Retractor muscles
5. Urethra
6. Seminiferous tubules
7. 4-7
8. Seminal vesicles
9. Cowper's gland
10. Sheath

11. Four of the following: Veterinarian, breed association representative, breeding services technician, livestock scientist, Extension livestock specialist, livestock producer, sales representative for livestock breeding products

12. j
13. f
14. g
15. i
16. k
17. a
18. h
19. d
20. e
21. b

22. a, b, c, d, f, h, i, l (question worth 12 points)

23. a, d, e, f, h, i, l (question worth 12 points)

24. b, c, d, e, h, i (question worth 10 points)

UNIT III - REPRODUCTION Name__________________

Lesson 1: Importance of Reproduction Date__________________
in Livestock

EVALUATION

Fill in the blank with the best answer.

1. The ______________ is the temperature-regulating structure of sperm production.

2. The tail of the ________________ stores the sperm.

3. The ___________________ straightens, causing an erection of the penis and allowing for copulation.

4. The _____________________ are used to retract the penis back into the sheath.

5. The ______________ is the canal inside the penis that carries sperm and urine.

6. The testes are made up of several thousand very small, tangled tubes that are called _________________________.

7. The testes must be _____ to _____ Celsius degrees lower than normal body temperature for sperm production to occur.

8. Secretions produced by the ____________________ make up 50 percent of the fluid in semen. These secretions consist of high concentrations of potassium and proteins.

9. The __________________ is a structure about the size of a walnut, which secretes fluids to clean out the urethra.

10. The ________________ is the structure that holds the penis in a fixed position in a non-erect state.

Complete the following short answer question.

11. List four careers associated with livestock reproduction.

    a.

    b.

    c.

    d.

Match the female reproductive term on the left with the definition on the right.

12. ____ Bladder
13. ____ Cervix
14. ____ Cotyledon
15. ____ Fallopian tube
16. ____ Infundibulum
17. ____ Ovary
18. ____ Uterus
19. ____ Urethral opening
20. ____ Vagina
21. ____ Vulva

a. Structure that produces the egg

b. External opening of the urinary and reproductive tracts

c. Sensory organ of the female reproductive tract

d. Opening for the bladder

e. Female organ where the semen is usually deposited at copulation

f. Seals the uterus from bacterial and foreign invasions after fertilization

g. Attachment point for connecting the placenta to the uterus

h. Where the fetus develops

i. Where the egg is fertilized

j. Storage place for urine

k. Funnel-like structure that connects the ovary to the Fallopian tube

Complete the following multiple answer questions.

22. Check the economic traits influenced by reproduction in beef cattle.

____ a. Calving interval
____ b. Carcass traits
____ c. Birth weight
____ d. Weaning weight
____ e. Horned
____ f. Maternal ability
____ g. Polled
____ h Daily rate of gain
____ i. Pasture gain
____ j. Type of diet
____ k. Daily water intake
____ l. Conformation score

23. For dairy cattle, check the economic traits influenced by reproduction.

____ a. Milk production
____ b. Horned
____ c. Type of idet
____ d. Percent fat
____ e. Udder support
____ f. Milking speed
____ g. Mastitis infection
____ h. Birth weight
____ i. Temperament
____ j. Daily water intake
____ k. Daily feed intake
____ l. Fertility

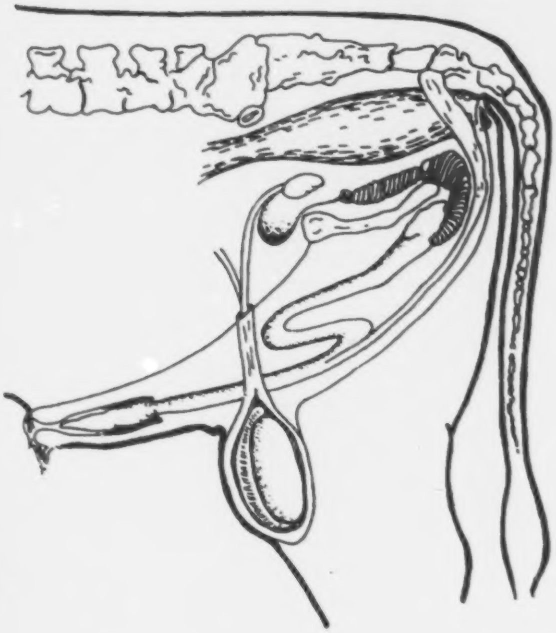
24. Check the economic traits influenced by reproduction in sheep.

____ a. Type of diet
____ b. Multiple births
____ c. Rate of gain
____ d. Finish or condition
____ e. Carcass quality
____ f. Polled
____ g. Daily water intake
____ h. Fleece weight
____ i. Wrinkles and skin folds
____ j. Number of lambs weaned

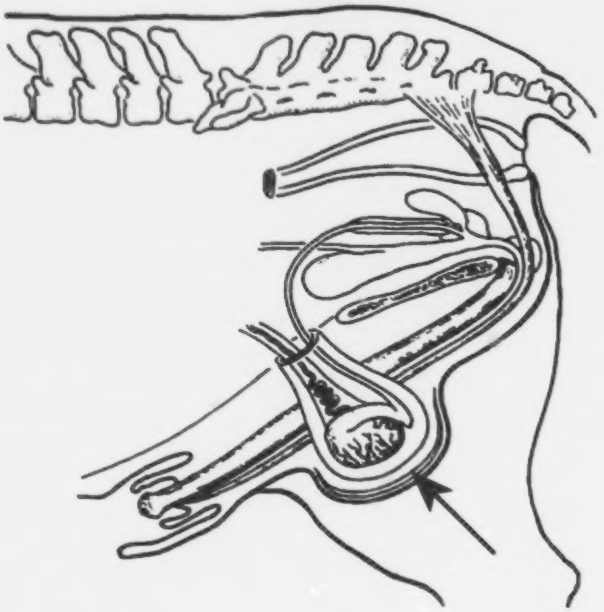
TM 1.1

Comparison of Male Livestock

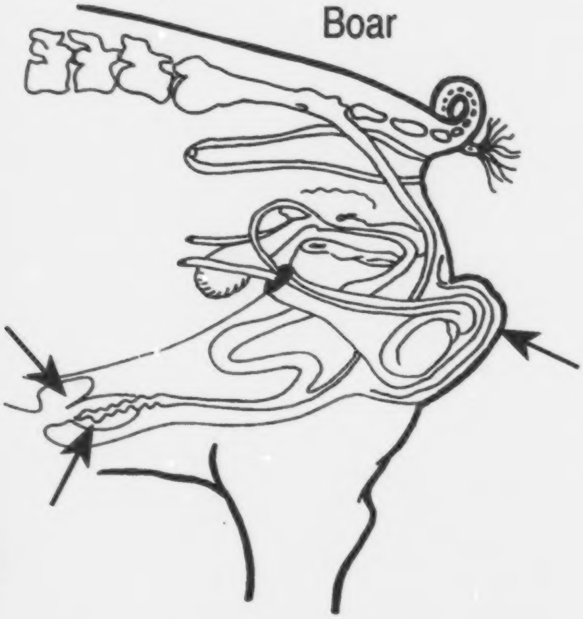
Bull



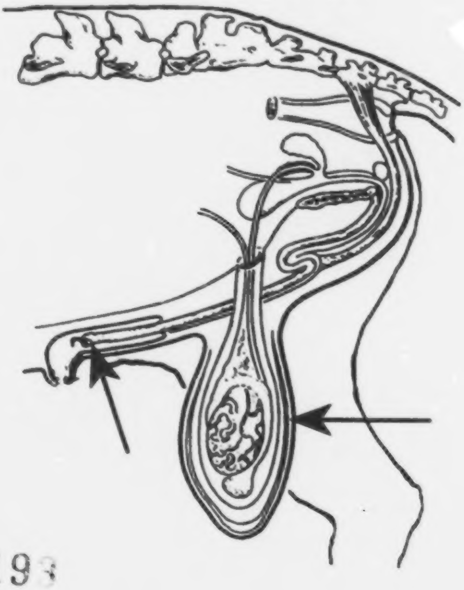
Stallion



Boar

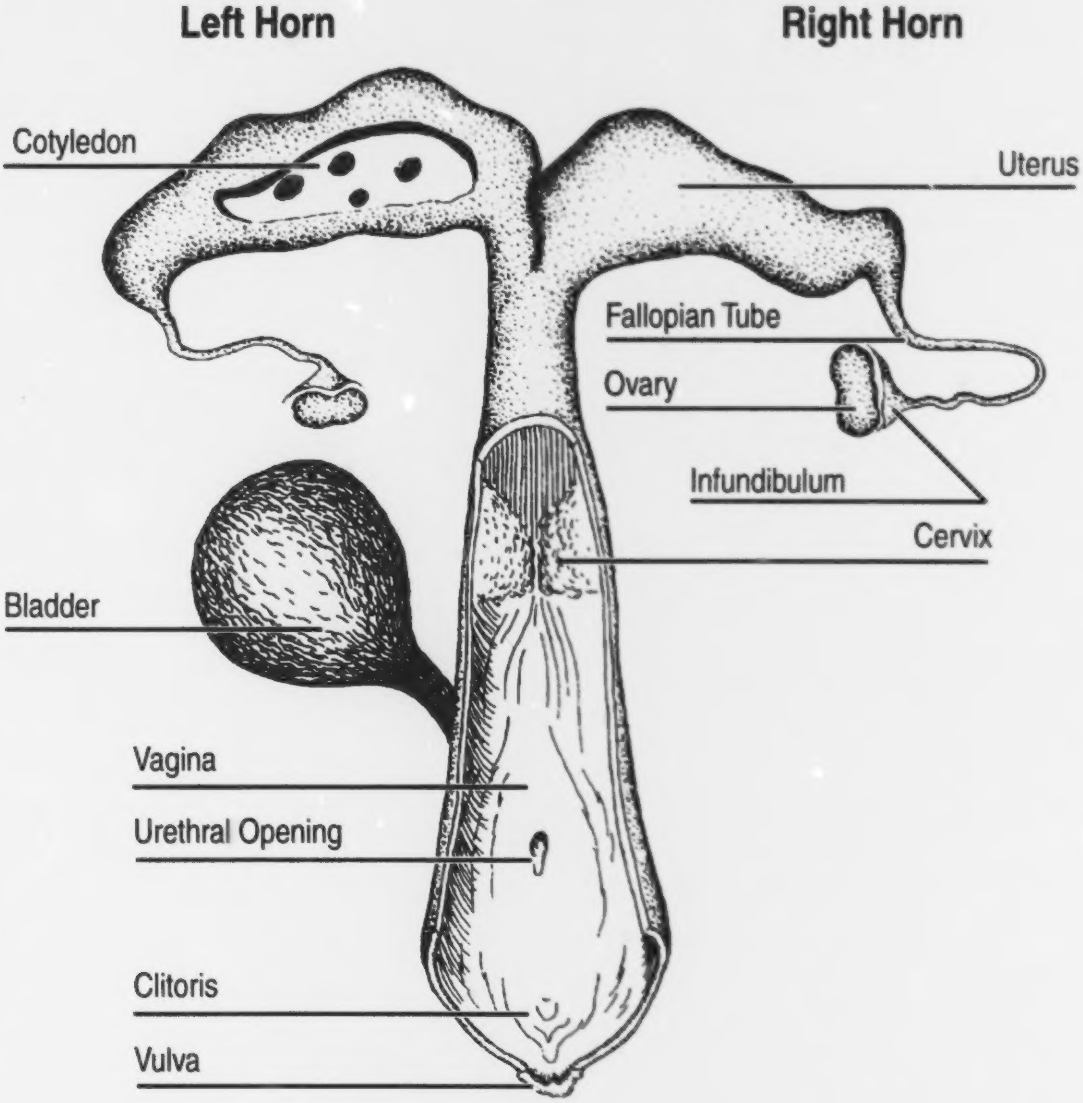


Ram



TM 1.2

Parts of a Cow's Reproductive Tract (Cut-Away View)


Left Horn
Right Horn
Cotyledon
Uterus
Fallopian Tube
Ovary
Infundibulum
Cervix
Bladder
Vagina
Urethral Opening
Clitoris
Vulva

UNIT III - REPRODUCTION

Lesson 2: Reproductive Hormones

Objective: The student will be able to describe the hormonal systems in livestock production.

Study Questions

1. **What are the common female reproductive hormones and their functions?**
2. **What are the common male reproductive hormones and their functions?**

References

1. Student Reference

UNIT III - REPRODUCTION

Lesson 2: Reproductive Hormones

TEACHING PROCEDURES

A. Review

Review the previous lesson.

B. Motivation

Most animal reproductive systems are regulated by the photoperiod--when day lengths begin to increase, the mating process begins. Offspring are born in the spring and summer and nurtured so they can survive the harsh winter months. However, most domesticated livestock are not seasonal breeders; instead, they have a continual breeding cycle. How is this breeding cycle regulated? Hormones regulate the reproductive systems of cattle, swine, sheep, and horses. Hormones aid in maintaining pregnancy, lactation, egg release, sex drive, and sperm formation.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss how hormones affect reproduction. Ask students to name some hormones that they think would be related to reproduction.

What are the common female reproductive hormones and their functions?

a) Hormones are substances produced in the animal's body. Various glands secrete natural hormones into body fluids, such as the bloodstream.
b) Estrogen is produced by the ovaries and has several effects.
    1) Body - Development of female sex characteristics
    2) Uterus - Causes uterine growth and contractions
    3) Mammary glands - Causes mammary duct growth
    4) Brain - Control of the estrous cycle
c) Follicle-stimulating hormone (FSH) is produced by the anterior pituitary gland. FSH stimulates follicular growth.
d) Luteinizing hormone (LH) is produced by the anterior pituitary gland.
    1) Effect on the gonads - Sends signal for ovulation
    2) Effect on the gonads - Stimulates production of progesterone, causes the maturation of follicles
    3) Maintains the corpus luteum
e) Progesterone is produced by the corpus luteum and is important for several effects.
    1) Uterus - Prepares reproductive tract for pregnancy, maintains pregnancy, and blocks uterine contractions
    2) Mammary glands - Causes mammary lobule-alveolar growth
    3) Brain - Blocks the estrous cycle
f) Oxytocin is produced by nerves in the brain and is stored in the posterior pituitary gland.
    1) Effect on the uterus - Causes uterine contractions
    2) Effect on the mammary glands - Milk let-down
    3) Effect on poultry - Causes the expulsion of eggs

g) Relaxin is produced in the corpus luteum of most livestock and in the placenta of mares.
   1) Effect on the cervix - Causes dilation
   2) Effect on the pelvic ligaments - Causes relaxation to assist in birth process

h) Prolactin is produced in the anterior pituitary gland.
   1) Initiates lactation
   2) Induces maternal behavior

i) Prostaglandin f-2-alpha is produced in the uterus. It causes corpus luteum regression.

2. Ask the students how the male hormones differ from the female hormones. Are there similarities?

What are the common male reproductive hormones and their functions?

a) Testosterone is produced by the testes and has several effects.
   1) Body - Development of sex glands and male sex characteristics
   2) Reproductive tract - Sperm formation (maturation) and seminal plasma production
   3) Brain - Sex drive control

b) Follicle-stimulating hormone (FSH) is produced by the anterior pituitary gland. FSH stimulates sperm formation (spermatogenesis).

c) Luteinizing hormone (LH) is produced by the anterior pituitary gland. It causes testosterone formation in the gonads.

F. Other activities

Bring in reproductive tracts of livestock. Trace when and where the hormones would affect reproductive cycle parts and production of the egg and sperm.

G. Conclusion

Hormones are chemical compounds that help regulate body functions. Hormones have a tremendous effect on the reproductive cycles of livestock. They control the development of sex characteristics, mating, and eventually fertilization. Therefore, hormones control the entire life cycle of livestock.

H. Competency

Describe the hormonal system in livestock reproduction.

I. Answers to Evaluation

1.	c
2.	d
3.	d
4.	a
5.	b
6.	c
7.	a
8.	b
9.	c
10.	d

UNIT III - REPRODUCTION

Name________________

Lesson 2: Reproductive Hormones

Date________________

EVALUATION

Circle the letter that corresponds to the correct answer.

1. Which hormone is responsible for female sex characteristics?
   a. Progesterone
   b. Oxytocin
   c. Estrogen
   d. Relaxin

2. Which hormone is produced in the placenta of mares but by the corpus luteum in other livestock?
   a. Oxytocin
   b. Prostaglandin
   c. Estrogen
   d. Relaxin

3. Which hormone is NOT produced by the anterior pituitary gland?
   a. Follicle-stimulating hormone
   b. Luteinizing hormone
   c. Prolactin
   d. Progesterone

4. Which hormone is responsible for alveolar growth in the mammary system?
   a. Progesterone
   b. Oxytocin
   c. Estrogen
   d. Testosterone

5. Which hormone is commonly given to lactating females to stimulate milk let-down?
   a. Estrogen
   b. Oxytocin
   c. Progesterone
   d. Relaxin

6. Which hormone sends the signal for ovulation?
   a. Estrogen
   b. Oxytocin
   c. Luteinizing hormone
   d. Follicle-stimulating hormone

7. Corpus luteum regression is caused by which hormone?

   a. Prostaglandin
   b. Relaxin
   c. Testosterone
   d. Follicle-stimulating hormone

8. Which hormone is responsible for the male sex characteristics and libido?

   a. Estrogen
   b. Testosterone
   c. Relaxin
   d. Luteinizing hormone

9. Sperm production is stimulated by which hormone?

   a. Relaxin
   b. Prostaglandin
   c. Follicle-stimulating hormone
   d. Estrogen

10. Which hormone blocks the estrous cycle?

   a. Follicle-stimulating hormone
   b. Estrogen
   c. Testosterone
   d. Progesterone

UNIT III - REPRODUCTION

Lesson 3: Reproductive Cycles of Common Livestock

Objective: The student will be able to understand and describe the reproductive cycles of common production livestock.

Study Questions

1. **At what age do different livestock species reach puberty?**
2. **Explain the estrous cycle and the interaction of hormones.**
3. **Explain spermatogenesis.**
4. **What are gestation lengths of various livestock?**

References

1. Student Reference
2. Activity Sheet

   AS 3.1: Reproductive Functions of Livestock

200

UNIT III - REPRODUCTION

Lesson 3: Reproductive Cycles of Common Livestock

TEACHING PROCEDURES

A. Review

Review previous lesson on hormonal systems in livestock production.

B. Motivation

What is puberty? How do we know when humans reach puberty? How is puberty stimulated? In humans, puberty occurs when male and female characteristics become more prominent than in the adolescent stage. Puberty begins with the release of hormones into the bloodstream that stimulates the growth of reproductive organs. Like humans, animals reach puberty in the same way. Animals mature at a much faster rate than humans, however. Most production livestock species have reached puberty by their first year of life.

C. Assignment

D. Supervised study

E. Discussion

1. Why is it so important that livestock producers understand when animals reach puberty? Discuss the differences among species.

At what age do different livestock species reach puberty?

a) Cattle
   1) The first sign of puberty in the female is the first estrous cycle, which begins at 8-12 months. This age difference depends on breed, nutritional, and environmental factors. Smaller breeds usually mature faster than larger breeds. A poor nutritional diet could delay puberty, as could poor environmental conditions.
   2) In the male, the first signs of puberty are the production of viable sperm and the desire to mount. Both signs are influenced by the hormone testosterone. These signs will begin to appear at 8-12 months. The desire to mount can appear earlier, but viable sperm are not present, usually.
   3) Heifers can be bred when they have reached 13-14 months or weigh 600-650 lbs. Bulls can begin servicing smaller numbers of females at 12 months.

b) Sheep
   1) The initial sign of puberty in the female is the first estrous cycle, which can begin at 8-10 months of age. The beginning of the estrous cycle depends on the type of breed, nutritional requirements, and environmental conditions. In general, ewe lambs of mutton breeds have their first estrous cycle in the fall of their first year. Ewe lambs are somewhat slower reaching their sexual maturity than ram lambs.
   2) The first signs of puberty in the male are the production of viable sperm and the desire to mount. These signs generally occur at 5-7 months.
   3) Ewe lambs can be bred after they have reached 12 months so that they lamb when they are approximately 24 months old. Young rams used for service before they are yearlings usually service smaller numbers of females.

c) Swine

1) Again, the first sign of puberty in the female is the first estrous cycle. The first estrous cycle can begin at 4-8 months. Most gilts do not begin their first cycle until they weigh 180 lbs. or more. The wide age range depends on the breed, environmental conditions, and especially nutrition.

2) Nutrition is extremely important because puberty is more centered around weight than age.

3) The first signs of puberty in the male are the production of viable sperm and the desire to mount. Again, the desire to mount usually comes before the production of viable sperm. The first sign of puberty generally begins at 4-8 months. Usually, boars take longer to reach sexual maturity than do gilts.

4) Gilts are usually bred to farrow at 11-12 months of age. In swine, breeding gilts largely depends on the development instead of age. A general rule is to breed gilts when they reach 225 lbs., not at a certain age. Boars can begin service at 8-12 months. Younger boars service smaller numbers of females in the earlier stages of their maturity.

d) Horses

1) In horses, sexual maturity is reached at 12-15 months. As in other classes of livestock, the first sign of puberty in the female is the estrous cycle. In the male, it begins with the production of viable sperm and the desire to mount. Puberty can be delayed by poor nutrition and poor environmental conditions.

2) The age to breed mares depends on the mare's maturity level. Well-developed mares have been bred as early as 2 years old to foal when they are 3 years old. It is best to breed mares when they are 3 years old so they foal when they are 4 years old. Stallions are ready for service when they reach puberty.

2. Understanding the interaction of hormones is important because hormones regulate the estrous cycle, which is the essence of livestock reproduction.

Explain the estrous cycle and the interaction of hormones.

a) Before puberty occurs, the female reproductive tract and ovaries slowly grow in size and show no functional activity. This growth seems to parallel the increase in body weight as the animal ages.

b) As puberty nears, the anterior pituitary gland releases FSH (follicle-stimulating hormones) into the bloodstream. FSH stimulates follicle growth in the ovary. Then, the ovarian weight increases and estrogen is released into the bloodstream. This stimulates growth in the other parts of the female reproductive tract.

c) When follicles mature, the egg is released by a hormone called LH (luteinizing hormone), which is also produced by the anterior pituitary gland. The luteinizing hormone ruptures the follicle and releases the egg (ovulation). Once ovulation has occurred, the animal has reached puberty.

d) Puberty is reached at different ages, depending on the species. The estrous cycle or heat period occurs when the female is willing to accept the male for mating. The estrous cycle begins with the release of estrogen from the ovaries, and the egg is ovulated.

e) The length of the heat period, the distance between heat periods, and the release of the egg are different in each class of livestock. Table 3.1 shows the differences for each class of livestock.

TABLE 3.1 - Differences in Estrous Cycles

Type of stock	*Length of heat period*		*Interval of heat period*		*When egg is released*
	Range	*Average*	*Range*	*Average*	*Time*
Cattle	6-30 hrs.	16-20 hrs.	19-23 days	21 days	12 hrs. after estrous is completed
Sheep	20-42 hrs.	30 hrs.	14-20 days	16-17 days	24-30 hrs. after estrous cycle is complete
Swine	1-5 days	2-3 days	18-24 days	21 days	36-40 hrs. after onset of heat
Horses	2-10 days	4-6 days	10-37 days	21 days	In latter part of the estrous cycle

f) Outward signs of the estrous cycle (heat period)
   1) How to find cows in heat
      (a) Cows in heat are under the influence of a sudden, high-level occurrence of the female sex hormone, estrogen. The egg-containing follicle which produces the hormone is at the height of its growth.
      (b) The nervous system is greatly affected. The cow is excitable and may bawl more than normal. She is restless and often walks the fences.
      (c) Cows in heat attempt to ride other cows. They stand to be mounted by other cows. Under conditions of natural service, they would stand and accept service by a bull. Standing is the only reliable, practical test for heat. When a cow stands, she is in heat and is ready for breedubg,
      (d) Ruffled hair over the tail head suggests that a cow has recently been ridden; she may or may not have been in heat. Many heifers and cows in heat flatten themselves down in the loin region. This presents a "sway back" and "high tail head" appearance.
      (e) Genital mucous may flow from the vulva in long strings. Wet mucous smears are often noticeable on the buttocks, over the pin bones, and under the tail.
      (f) The vulva of a cow in heat appears somewhat swollen.
      (g) In the second or third day after heat, but sometimes earlier, bloody mucous passes from the cow's vulva. Bleeding from the cow means that she has been in heat (ovulation implied) 2-3 days before.
   2) Females of other livestock classes show similar conditions to some of those described for cows in heat.
   3) When checking heat for artificial insemination purposes, check for heat at least twice each day. Animals in pasture must be carefully observed.

3. Discuss how sperm is produced and how an offspring's sex is determined.

Explain spermatogenesis.

a) Spermatogenesis is the production of viable sperm within the seminiferous tubules. The process occurs through meiosis and mitosis.
b) The process of spermatogenesis
   1) The process starts with spermatogonia, which are carriers of both sets of chromosomes (XY). Spermatogonia are sex cells in the form of immature sperm. Spermatogonia become mature sperm through spermatogenesis. The spermatogonium has two X chromosomes and two Y chromosomes.

2) Mitosis is cell division where one cell divides into two separate cells, both containing two complete sets of chromosomes.
3) In meiosis, the sex cell division splits the number of chromosomes in half.
4) Spermatogonia divide by mitosis, making like cells with two X chromosomes and two Y chromosomes. A diploid occurs with two X chromosomes and two Y chromosomes.
5) The first meiotic division occurs when the diploid is split in half, creating a haploid. A haploid has only one X chromosome and one Y chromosome. This haploid divides one more time through meiosis.
6) Once this division occurs, the new haploid is left with either an X or a Y chromosome; it does *not* possess both. This decides the sex of the offspring.
7) Before the second haploid becomes a mature sperm, it must first go through a metamorphosis. During this metamorphosis, the haploid receives a head and a tail to move through the female reproductive tract.
8) Once this haploid changes into a mature sperm, it becomes a male or female, depending the chromosome it carries. The sperm determines the sex of the offspring by which type of sperm reaches the egg first.
9) This whole process of spermatogenesis takes about 46-49 days to occur.

4. It is important that livestock producers understand gestation periods so they can prepare for calving or farrowing times.

What are gestation lengths of various livestock?

a) Gestation or pregnancy period is the length of time between fertilization and the birth of the offspring (parturition).
b) To understand gestation, begin with the ruptured follicle that released the egg. This ruptured follicle develops into an endocrine gland called the corpus luteum.
    1) The endocrine gland produces hormones for the reproductive system.
    2) The corpus luteum produces a hormone called progesterone, which helps maintain pregnancy.
c) Once the egg is fertilized, it floats freely in the uterus for a while. After a short time, the fertilized egg begins development of the placenta. The placenta is attached to the uterus by the cotyledons, which keeps the placenta in place for the remainder of the gestation period.
d) Gestation lengths vary from one class of livestock to another. Table 3.2 shows the differences of gestation lengths in each class of livestock.

TABLE 3.2 - Gestation Length

Livestock	*Range (days)*	*Average*
Cattle	240-330	283 (9.5 months)
Swine	111-115	114 (3.8 months)
Sheep	144-152	148 (5 months)
Horses	315-350	336 (11 months)

F. Other activities

Have students do Activity Sheet 3.1. This sheet will help coordinate estrous cycle, gestation, spermatogenesis, and puberty.

204

G. Conclusion

It is especially vital for any livestock producer to understand the reproductive cycle of livestock. This understanding aids producers in making decisions about AI programs, hand or pasture mating, determining the number of females per male, and the age at which to breed young stock.

H. Competency

Describe the reproductive cycle of common production livestock.

Related Missouri Core Competencies and Key Skills

10A-2: Distinguish between mitosis and meiosis
10B-4: Describe the structure and function of (human) reproductive organs

I. Answers to Evaluation

1. Nutrition, environment or breed
2. Mitosis
3. Meiosis
4. Diploid
5. Follicle
6. Follicle-stimulating hormone
7. Haploid
8. Testosterone
9. Estrous cycle
10. Estrogen
11. Viable sperm, desire to mount
12. Spermatogenesis
13. Progesterone
14. Anterior pituitary
15. Swine
16. Ovulation
17. Corpus luteum
18. Ram, ewe
19. Gilt, boar
20. Fall
21. 283 days, 21 days
22. 114 days, 21 days
23. 148 days, 16-17 days
24. 336 days, 21 days

J. Answers to Activity Sheet 3.1

	Cattle	Sheep	Swine	Horses
Age at which male reaches puberty	8-12 mos.	8-10 mos.	4-8 mos. or 180 lbs.	12-15 mos.
Age at which female reaches puberty	8-12 mos.	5-7 mos.	4-8 mos.	12-15 mos.
Length of heat period (average)	16-20 hrs.	30 hrs.	2-3 days	4-6 days
Interval of heat period (average)	21 days	16-17 days	21 days	21 days
Time when egg is released (average)	12 hrs. after estrous is completed	24-30 hrs. after estrous is completed	24-30 hrs. after estrous is completed	In the latter part of estrous
Gestation length (average)	283 days	148 days	114 days	336 days
Age/size at which to breed females that have reached first estrous cycle	13-14 mos. or 600-650 lbs.	12 mos.	11-12 mos. or 225 lbs.	3 yrs. old
Age/size at which males can begin service	12 mos.	12 mos.	8-12 mos.	12-15 mos.

UNIT III - REPRODUCTION Name______________

Lesson 3: Reproductive Cycles of Common Livestock Date______________

EVALUATION

Fill in the blank with the best answer.

1. Puberty can be delayed by ______________ and ________________________ in livestock.
2. Cell division, in which one cell divides into two separate cells containing two complete sets of chromosomes, is called ____________.
3. Cell division, in which one cell divides and the chromosomes are equally divided between the two cells, is called ____________.
4. A spermatogonium that possesses two X chromosomes and two Y chromosomes is called ____________.
5. The egg is released through the rupture of a ____________ in the ovary.
6. FSH stands for ________________________________.
7. A spermatogonium that possesses one X chromosome and one Y chromosome is called ____________.
8. The male sex hormone responsible for sperm production is called __________________.
9. The first sign of sexual maturity in the female is the ________________.
10. The hormone released by the ovaries before puberty is reached is called ______________.
11. In the male, the first signs of puberty are _________________ and ____________________.
12. The process of producing viable sperm in livestock is called ____________________.
13. The hormone called _________________ maintains pregnancy in livestock.
14. The luteinizing hormone and FSH are produced by the ____________________ gland.
15. A poor nutritional diet affects the delaying of puberty more in _________________ than in any other class of livestock.
16. The release of the egg from the follicle is called ______________.
17. The hormone used to maintain pregnancy in livestock is produced by the __________________.
18. In sheep, generally the _________ reaches sexual maturity before the _________.
19. In swine, generally the __________ reaches sexual maturity before the __________.
20. In sheep, ewe lambs usually have their first estrous cycle in the _________ of their first year of life.

Fill in the blanks with the correct answer for each class of livestock.

		Gestation length Ave. days (±2)	*Interval of heat period* Ave. days (±2)
21.	Cattle	________	________
22.	Swine	________	________
23.	Sheep	________	________
24.	Horses	________	________

Lesson 3: Reproductive Cycles of Common Livestock

Name_______________

Reproductive Functions of Livestock

Fill in the answers for each class of livestock.

	Cattle	Sheep	Swine	Horses
Age at which male reaches puberty				
Age at which female reaches puberty				
Length of heat period (average)				
Interval of heat period (average)				
Time when egg is released (average)				
Gestation length (average)				
Age/size at which to breed females that have reached first estrous cycle				
Age/size at which males can begin service				

203

UNIT III - REPRODUCTION

Lesson 4: Fetal Developmental Stages

Objective: The student will be able to sequence the fetal development stages of livestock.

Study Questions

1. **Describe the developmental stages of the livestock fetus and mother during gestation.**
2. **Describe the developmental stages of the embryo (egg) and hen during incubation.**
3. **What are the nutritional requirements during the different stages of pregnancy and lactation?**

References

1. Student Reference
2. *Agriscience 332: Animal Science (Student Reference).* Texas A & M University: Instructional Materials Service, 1989.

UNIT III - REPRODUCTION

Lesson 4: Fetal Developmental Stages

TEACHING PROCEDURES

A. Review

Review the gestation lengths of livestock from Agricultural Science I and the previous lesson.

B. Motivation

Bring in reproductive tracts with fetuses in different stages of development. These can be obtained from a local veterinarian or a meat locker. Discuss the different stages observed.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss how the fetus grows and how it affects the mother during gestation.

Describe the developmental stages of the livestock fetus and mother during gestation.

a) The development and growth of the livestock fetus is similar across species, but the rate of growth varies due to the differences in gestation length. Therefore, general terms will be used when describing fetal development.

b) Animal life begins as a single cell (the fertilized egg). Through the processes of cell division, this cell multiplies and develops into a mature animal. Growth includes all of the physiological processes that allow the fertilized egg to develop into a many-celled animal.

c) Prenatal development

1) During embryonic growth, all body cells increase in size and number.

2) Prenatal growth pertains to the development prior to birth. It involves the time between birth and fertilization of the ovum by the sperm (forming a zygote).

3) The zygote begins as one cell containing chromosome pairs, one each from the father and mother. The zygote's single cell begins a series of divisions into two cells, then four, then eight, etc.

4) The newly fertilized egg free-floats in its mother's reproductive tract. This embryo spends the first few days traveling in the oviduct toward the uterus. By the time it reaches the uterus, 16 or more cell divisions have taken place.

5) After reaching the uterus, the egg continues to free-float and absorb nourishment from fluids in the uterus. The embryo is surrounded by a set of membranes called the placenta (afterbirth).

(a) In hogs, the entire placenta attaches to the entire surface of the uterus.

(b) In sheep, cattle, and horses, there are cotyledons (button-like spots on the placenta) which attach to caruncles (spots) on the uterus. These points of attachment, along with the arteries and veins in the umbilical cord, provide the embryo with nourishment from the mother and waste disposal.

6) The cells then go through morphogenesis, a process of differentiation in which cells are organized into specific structures. Cells divide into three basic layers: ectoderm, mesoderm, and endoderm.

(a) Ectoderm
    (1) Brain and other parts of the central nervous system
    (2) Skin, hair, wool, and hooves
    (3) Certain endocrine glands
(b) Mesoderm
    (1) Voluntary muscle tissue
    (2) Involuntary muscle tissue (heart)
    (3) Circulatory system
    (4) Connective tissue - bone, cartilage, ligaments, and tendons
(c) Endoderm
    (1) Liver
    (2) Digestive system
    (3) Other endocrine glands

7) Body organs develop in a specific sequence. The head is formed before the tail, and the beginning of the spinal cord is formed before other organs.

8) The rate of prenatal growth in animals livestock varies among species due to the varying lengths of gestation. Although the rate of prenatal growth varies, most young are born at the same stage of maturity.

TABLE 4.1 - Timetable of calf development

	Time (days)	Development
First trimester	0	Fertilization in oviduct
	4	Embryo (in eight- to 16-cell stage) reaches uterus.
	8-11	Embryo transfer possible
	12	Embryo forms weak attachment to uterine wall
	18	Amnion encloses embryo.
	21	Heart begins to beat; reproductive tract begins to develop.
	23	Head region is recognizable.
	25	Forelimb buds appear.
	30	First placental plates appear.
	33	Fragile cotyledonary attachment forms.
	37	Facial features appear.
	46	Developing animal is now a fetus.
	60	Eyelids able to close.
Second trimester	100	Horn pits appear.
	110	Tooth development begins.
Third trimester	230	Hair covers the body.
	283	Birth

2. Discuss how egg incubation is similar and different from the gestation of other livestock.

Describe the developmental stages of the embryo (egg) and hen during incubation.

a) In birds, the process of incubation (causing something to develop or take form) corresponds to gestation in mammals.

b) Terms
   1) Amnion - the sac that surrounds the embryo
   2) Chorion - the lining between the egg shell and the internal portion of the egg
   3) Allantois - part of an egg which stores excretory wastes; fills the space between the amnion and the chlorion

c) When fertilization occurs in poultry, the embryo begins development around a well-defined germinal disk. This area is clearly visible to the naked eye when a freshly laid, fertilized egg is broken.

d) Within 48 hours after fertilization, a chick embryo establishes an intricate blood circulation system between itself and the life-sustaining yolk. Since there is no placenta, as in mammals, the poultry embryo has to depend on this intricate blood vessel network to provide nutrients and remove wastes.

e) By the end of the third day, the embryo has a full set of membranes. The allantois, which stores excretory wastes, fills the space between the amnion and the chorion.

f) The allantois then merges with the chorion to form the chorio-allantois, which expands and contacts the shell membrane. The chorio-allantois serves as the respiratory organ for the developing embryo until the pulmonary organ takes over about 24 hours after hatching.

g) The shell and the membranes also protect the developing embryo from harmful microorganisms or molds.

h) The embryo floats within the fluid in the amniotic cavity. The developing embryo (chick) is protected by this floating movement, which must continue until the last 3-4 days before hatching. Without the movement, malformations can occur that endanger the life of the newborn chick.

i) In an incubator, the egg must be turned several times a day to prevent adhering of the embryo to the chorio-allantois membrane. In nature, the hen instinctively shifts the egg several times a day.

j) Physical factors necessary for incubation and hatching
   1) Temperature - Outside the incubator, store the eggs for a maximum of seven days at 60°F. This allows for development processes to continue without adverse effects after the eggs are placed in the incubator. Maintain a temperature range of 98-104°F within the incubator.
   2) Humidity - Since the egg is approximately 70 percent water, it is important to maintain a certain humidity to prevent water loss. Pre-incubation storage of hatching eggs should be at 85 percent humidity and 60-65 percent humidity during incubation.
   3) Air velocity - A constant supply of fresh air is necessary for the developing embryo.
   4) Energy supply

TABLE 4.2 - Timetable of chick development

Time (days)	Development
3	Blood circulation between embryo and yolk is established.
5	Sex can be determined.
8	General outline is recognizable.
8-9	Lungs, nervous, muscular, and sensory systems are in place.
10-11	Embryo is covered with down and first feathers.
21	Hatching occurs.

3. Discuss how the nutritional requirements change during gestation. Relate back to Unit I - Nutrition.

What are the nutritional requirements during the different stages of pregnancy and lactation?

a) Cattle
   1) The period during which the calf crop is affected most by nutrition extends from 30 days before calving until 70 days after calving.
   2) The nutritional needs of nursing cows are greater and more critical than those of pregnant cows. After a cow calves, her energy needs jump about 50 percent; her protein needs double; her calcium and phosphorus needs triple.
   3) During the last three months of pregnancy, the nutritional requirements are higher than for an open female because of the requirements of the growing fetus.

b) Sheep (Goats)
   1) Pregnant ewes - In general, feeding a suitable, well-balanced ration with necessary minerals and vitamins will ensure a strong, healthy lamb crop.
   2) During the last 4-5 weeks of pregnancy, the fetus develops rapidly, and the demands on the ewe are heavy. Ewes should be fed 0.5-1 pounds of grain per head daily during this period.
   3) Lactating ewes - Following lambing, the feed allowance of the ewe should be increased according to her capacity and needs. Though varying somewhat with size and condition of the ewe (and whether she is raising twins or a single lamb), an adequate ration could consist of 4 lbs. of high-quality alfalfa hay plus 1-2 lbs. of grain daily.

c) Swine
   1) Pregnant sows - Approximately two-thirds of the fetal growth occurs in the last month. During gestation, it is important that body reserves be stored for lactation. Feed should be increased to 4-5 lbs. per day.
   2) Sows should not be overfed because fat sows have farrowing difficulties. Four to five days before farrowing, it is a good practice to decrease feed intake and feed a bulky, laxative feed.
   3) Lactating sows - The nutrient requirements of a lactating sow are more rigorous than those during gestation. The lactating sow should be fed 2.5-4.5 lbs. daily for each 100 lbs. of body weight.

F. Other activities

1. Obtain an incubator for poultry eggs. Buy some fertilized eggs and keep them until hatching occurs. Until hatching time, have students chart what should be occurring each day of incubation.

2. Track the development of the fetus and mother of someone's SAE project.

G. Conclusion

Although gestation periods of various species of livestock differ, the stages of fetal growth and the effects of gestation on the mother are very similar. The growth of the fetus is just more rapid when the length of gestation is shorter. To ensure a safe pregnancy and healthy offspring, it is important to make management changes that relieve stresses placed on the mother during gestation.

H. Competency

Sequence the fetal developmental stages of livestock

Related Missouri Core Competencies and Key Skills

10B-4: Describe the structure and function of (human) reproductive organs
10C-7: Sequence the developmental stages of the (human) fetus

I. Answers to Evaluation

1. a
2. c
3. b
4. d
5. a
6. b
7. c
8. Temperature, humidity, air velocity, energy supply

UNIT III - REPRODUCTION

Name_______________

Lesson 4: Fetal Development Stages

Date_______________

EVALUATION

Circle the letter that corresponds to the best answer.

1. What does the ectoderm develop into?

    a. Brain
    b. Digestive system
    c. Liver
    d. Connective tissues

2. The mesoderm develops into the ____________________________.

    a. Digestive system
    b. Hair, skin, and hooves
    c. Connective tissue
    d. Brain

3. What does the endoderm develop into?

    a. Involuntary muscle tissue
    b. Liver
    c. Connective tissue
    d. Brain

4. When does the female require the most nutrition?

    a. Breeding
    b. Gestation
    c. Grazing
    d. Lactation

5. The sac surrounding the embryo within an egg is called the _________________.

    a. Amnion
    b. Placenta
    c. Chorion
    d. Allantois

6. The placenta of sheep, cattle, and horses attaches to the uterus at points called ____________________________.

    a. Allantois
    b. Cotyledons
    c. Oviduct
    d. Mesoderm

7. Which pregnant females benefit from a decrease in feed intake for the last 4-5 days before giving birth?

   a. Sheep
   b. Goats
   c. Swine
   d. Cattle

Complete the following short answer questions.

8. List the four physical factors that limit the incubation and hatching of eggs.

   a.

   b.

   c.

   d.

UNIT III - REPRODUCTION

Lesson 5: Effects of the Environment on Reproduction

Objective: The student will be able to identify the effects of the environment on the reproductive cycle of breeding stock.

Study Questions

1. **How does nutrition and body condition affect the reproductive cycle?**
2. **How does the photo period affect different species of livestock?**
3. **How does temperature affect the reproductive cycle?**

References

1. Student Reference
2. Body Condition Poster. Columbia, MO: Feed Division, MFA, Inc.

UNIT III - REPRODUCTION

Lesson 5: Effects of the Environment on Reproduction

TEACHING PROCEDURES

A. Review

Review previous lesson on fetal development stages in livestock

B. Motivation

Ask students if plant growth is affected by the photo period, environmental conditions, and fertilization requirements. Well, animals are affected by the same three factors. Both plants and animals are affected by the length of daylight hours. Like plants, animals that do not receive the correct amount of nutrients have reproductive (growth) problems. Finally, plant growth is greatly influenced by extreme heat, cold, lack of water, and excess water. Like plants, livestock reproductive difficulties become more apparent during extreme environmental conditions. If animals cycle naturally and receive adequate nutrition and temperature, they will also reproduce abundantly.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss why body condition and nutrition are important factors in animal reproduction. Use the body condition chart from MFA to illustrate different levels of conditioning.

   How does nutrition and body condition affect the reproductive cycle?

   a) How nutrition affects reproductive failure in females
      1) Nutrition is related to several reproductive difficulties, which are more prominent in younger females than in more mature females.
         (a) Once the breeding season begins, a small percentage of females come into their heat period in the first 21 days after giving birth, which results in a longer calving season.
         (b) A lower percentage of females conceive on the first service by the sire, which also results in a longer calving season and more unproductive days.
         (c) A higher percentage of calf deaths at birth and within the first two weeks causes extreme losses for that year.
      2) All these difficulties can be prevented through a proper diet. Livestock producers must be aware of the nutritional requirements for females during lactation, gestation, and the pre-breeding period.
      3) Flushing is a nutritional technique used by swine and sheep producers to prepare breeding stock for the breeding season. Flushing keeps sows and ewes on a full feed ration to allow the body and reproductive tract to build back up before the next breeding. If this method is used, reproductive problems associated with nutrition will be reduced.
      4) Nutrition is critical during the 100-day pre-birth period. Most reproductive failures are caused by deficiencies in one or more nutrients during the pre-birth 100-day period and the days immediately following birth. During this period, conception rates and calving deaths are determined for the next breeding season.

5) Research on animal reproduction problems shows significant breakthroughs.

(a) Energy is more vital than protein when it comes to reducing reproductive problems.

(b) Livestock receiving inadequate levels of energy reproduce at a lower level.

(c) Low phosphorus diets decrease calf crop.

(d) Supplements of vitamin A to bred heifers on a dry forage diet will increase calf crop.

(e) The amount and type of feedstuffs fed before and after calving determine conception rate and proper timing of heat periods for the next breeding season. Feed requirements increase after calving, so feeding allowances must parallel this need. If this does not occur, the female will have severe weight loss, which will delay heat cycle and decrease conception rate.

(f) The condition of the female also has an effect on reproductive difficulties. The poorer her condition, the greater the reproductive difficulties become.

(g) An average conditioned cow should gain a minimum of 100 lbs. during gestation. After calving, an average conditioned cow should gain ½ to ¾ lb. daily to build up reserves for next breeding season.

(1) A thin cow should also have a 100 lb. minimum gain during gestation. After calving, a thin cow should gain 1½ to 2 lbs. daily to build up reserves for next breeding season.

(2) Nutrition should not be ignored during gestation and after giving birth. A proper diet during these periods will produce healthier calves, lower mortality rates, quicker breed back, and longer female productive life. These procedures also apply to other classes of livestock.

6) In prepubertal females, a restricted or nutrient-lacking diet can delay puberty or cause hypoplasia. Hypoplasia is the defective or incomplete development of reproductive organs, which usually accounts for reproductive organs remaining below normal size.

(a) Nutritional disorders can be detected in females by lack of an estrous cycle or signs of puberty.

(b) Nutritional disorders can be solved through proper diets. If caught in time and started on a proper diet, prepubertal females with a delayed puberty can resume normal growth in reproductive organs.

b) How nutrition affects reproductive failure in males

1) Reproductive failures due to nutritional disorders have greater effects on younger bulls than more mature sires. Older sires can manage for a year on a poor or deficient diet without decreasing sperm numbers. Older sires use body reserves to maintain proper sperm production.

2) Younger or prepubertal sires can be greatly influenced by improper nutritional diet. A poor diet can delay puberty and can be fatal if the nutrient deficiency is extreme enough. A nutritional deficiency in younger sires can cause irreparable damage if continued for long periods of time. This damage results in reduced testes size, low sperm production, and slow sperm replenishment.

2. Ask students to describe photo period and how it affects reproduction in livestock.

How does the photo period affect different species of livestock?

a) Photo period refers to the length of daylight hours in a day. Like plants, animals are influenced by the hours of light. Imported livestock breeds had to adjust to their new environment's photo period. Sometimes, these new breeds never adjusted to their new environment and they could not reproduce in this country.

b) The photo period affects different species of livestock.

  1) Cattle are considered continuous breeders. Most beef producers aim for calving during September, October, and November, so the breeding season is during the months of January, February, and March.
  2) Swine are also continuous breeders. For this reason, most confinement pork producers plan breeding systems to keep their farrowing houses full year-round. For producers farrowing twice a year, breeding systems are more influenced by heat, funds available, and available feeds, not by photo period. Feed costs aren't significant in breeding swine since they are continually fed.
  3) Sometimes, horses are considered continuous breeders. The breed has a greater influence on the reproductive cycle than the photo period, since most equine breeds originated overseas. Horses do show more sexual activity during the spring months, however.
  4) Sheep are not considered continuous breeders, but some sheep breeds can produce more than one lamb crop per year. Generally, the sheep breeding season is stimulated by the photo period. Estrous cycles usually begin in September and end in March. The Dorset breed has the longest breeding season, which begins in June and ends in April, allowing for two lambing seasons. Sheep are heavily influenced by the shortening of day hours.
  5) The early ancestors of poultry only laid eggs in the spring months. Through selection and improved management techniques, poultry now lay continuously. Photo period has the greatest influence on poultry because the bird's optic nerve is sensitive to light intensity. When light intensity increases, activity in the pituitary gland increases. The increased pituitary gland activity continues hormone production, which stimulates the reproductive cycle. Continual light in hen houses is the sole reason for continuous laying by hens.

3. Ask students if they know of other factors affecting the reproductive cycle in livestock.

How does temperature affect the reproductive cycle?

a) In the female

  1) Heat stress affects female reproductive cycle in many ways. Extreme heat can delay the estrous cycle in many classes of livestock, especially sheep. Sheep have a limited breeding season and do not show external signs of the estrous cycle during the hot summer months. Sheep do not begin showing signs of heat until late summer and early fall months.
  2) Extreme heat also influences offspring weights at birth. Extreme heat causes the female to expel more energy for cooling instead of using that energy for the offspring, which creates low birth weights. Extreme heat causes a lack of appetite in animals, which decreases feed intake, which reduces the amount of nutrients going toward the offspring.
  3) During the last trimester, extreme heat conditions can be detrimental. These extreme heat conditions cause abortions, fetal deaths, low birth weights and litter sizes, and abnormality in offspring.
  4) Placenta size is reduced under extreme heat conditions, which can cause birthing difficulties.
  5) Extremely cold temperatures usually do not have the same impact on reproduction. When extremely cold temperatures do occur, usually the only result is a lower birth weight. During extreme cold temperatures, the female uses more energy to control body temperatures.

b) In the male

  1) Environmental conditions affect reproduction in the male, but to a lesser degree. A fluctuation of testosterone production does not occur during extreme heat

conditions, but there is a fluctuation in sperm production and increased sperm abnormalities. Seasonal variations in sperm production have little effect on the reproduction efficiency of sires.

2) The number of females serviced during extreme heat is decreased because sires become exhausted more quickly.

3) Extreme cold temperatures usually do not affect male reproduction because most breeding seasons do not occur during these periods.

F. Other activities

1. For Body Condition Posters, contact:

   Feed Division, MFA Agri Services
   615 Locust
   Columbia, MO 65201
   573/876-5244

2. Have students set up a breeding schedule for each class of livestock considering the factors of photo period, nutrition, and environmental conditions.

G. Conclusion

For people associated with livestock production, it is vital to have a good knowledge of factors influencing the reproductive cycle. The maximum number of offspring results in more profits for the operation. Knowing that nutrition, photo period, and environmental conditions influence livestock reproduction will greatly improve monetary success for a producer.

H. Competency

Describe the effects of the environment on the reproductive cycle.

Related Missouri Core Competencies and Key Skills

10A-7: Describe the significance of the light and dark phases of photosynthesis

I. Answers to Evaluation

1. Photo period
2. Younger, older
3. Lower
4. Optic nerve
5. Poultry, sheep
6. Pituitary
7. Abnormalities
8. Swine, cattle
9. Energy, protein
10. Puberty
11. a, c, g (question worth 7 points)
12. a, d, e, f (question worth 6 points)

UNIT III - REPRODUCTION Name______________

Lesson 5: Effects of the Environment on Reproduction Date______________

EVALUATION

Fill in the blank with the best answer.

1. The amount of daylight hours is called the _________________.

2. Reproductive difficulties created by nutrition are more predominant in ____________ females than __________ females.

3. If nutritional deficiencies are present in the diet, a __________ percentage of females conceive on the first service by the sire.

4. In poultry, the ________________ is responsible for detecting light intensity.

5. The two classes of livestock that are influenced the most by the amount of daylight hours are ____________ and __________.

6. In poultry, increased light intensity increases activity in the ______________ gland.

7. Extreme heat periods increase sperm __________________ in the testes of the male.

8. Because their estrous cycles continue throughout the year, __________ and ___________ are considered to be continuous breeders.

9. When reducing reproductive problems in gestating females, the nutrient ___________ is more vital than the nutrient ____________ when figuring rations.

10. A poor nutritional diet can delay ____________ in young females.

Complete the following multiple answer questions.

11. Check all the factors associated with extreme heat and reproductive problems in female livestock.

____ a. Can delay the estrous cycle
____ b. Can advance the estrous cycle
____ c. Can reduce birth weights
____ d. Can increase placenta size
____ e. Affects the first trimester more than the last trimester
____ f. Affects the second trimester more than the last trimester
____ g. Can increase the number of abortions

12. Check all the factors describing ways nutrition can affect reproductive problems in livestock.

____ a. Low phosphorous diets decrease calf crop.
____ b. Vitamin C supplements to bred heifers on dry forage diets increase calf crops.
____ c. Protein is more vital than energy in reducing reproductive problems.
____ d. A poorly conditioned female will have greater reproductive difficulties.
____ e. Feed requirements increase after calving.
____ f. An average conditioned cow should gain a minimum of 100 lbs. during gestation.

UNIT III - REPRODUCTION

Lesson 6: Management and Technology in Reproduction

Objective: The student will be able to describe management and technology utilization to affect the reproductive cycle of livestock.

Study Questions

1. **What is artificial insemination (AI) and why is it important?**
2. **What is estrous synchronization and why is it important?**
3. **What products are available for estrous synchronization?**
4. **What is embryo transfer (ET) and when should it be utilized?**
5. **What is sexing semen and what is its economic importance?**
6. **What is cloning?**

References

1. Student Reference

UNIT III - REPRODUCTION

Lesson 6: Management and Technology in Reproduction

TEACHING PROCEDURES

A. Review

Review the previous lesson.

B. Motivation

1. Work with a local veterinarian and producer to get a semen sample from a local producer's bull. Bring in the semen sample and prepare slides for your class to view under a microscope.

2. Bring in samples of products used for estrous synchronization. Discuss uses of the products.

3. Bring in AI tools and possibly a reproductive tract or model cow to demonstrate the techniques.

C. Assignment

D. Supervised study

E. Discussion

1. Ask the students to explain AI's purpose and on which animals it might be used.

What is artificial insemination (AI) and why is it important?

a) Introduction of male reproductive cells (sperm) into the reproductive tract of a female by artificial means
b) History of AI
    1) The origin of AI is unclear, but an Arabian legend dating to 1322 maintains that the method was first used by a chieftain who had stolen the "seed" of an enemy's stallion to deposit into his own mare.
    2) The first recorded scientific research in AI of domestic animals was done on dogs by an Italian physiologist in 1780. By the late 1800s, American veterinarians used it to get mares in foal that consistently did not settle by natural methods.
    3) Today, AI is used extensively in the U.S. in many species of livestock. However, the greatest use of AI is in the dairy industry.
c) Benefits of using AI
    1) Increased uniformity
    2) Economics
    3) Better health protection (no venereal contact)
    4) Improved herd records
    5) Shorter time turnaround
d) Limitations of AI
    1) Training needed
    2) Inferior genetic traits perpetuated, as well as superior ones
    3) Some potential for abuse
    4) Requires more time and management
e) Two methods of semen collection
    1) Artificial vagina

- 2) Electrical stimulation in conjunction with the artificial vagina

- f) Semen processing
  - 1) Testing semen
    - (a) Semen density is tested to estimate the number of sperm in the semen.
    - (b) Semen is examined under a microscope to determine mobility. If 80 percent or more of the sperm move, the "percent mobility" is good.
  - 2) Extending semen
    - (a) Millions of sperm are ejaculated by the male at mating. An ejaculation can now be extended or diluted (so that many more females can be bred with it). This is accomplished by adding materials to the semen that help keep the sperm alive and increase the volume.
    - (b) Common extenders are listed in Table 6.1.

TABLE 6.1 - Semen Extenders

Type of diluent	Animals used for
Egg-yolk citrate	Bull, ram
Egg-yolk phosphate	Bull, ram, stallion
Homogenized milk	Bull, ram, boar
Glycine-containing diluents	Boar

- g) Storing semen
  - 1) After special treatment of semen with extenders, the sperm can withstand freezing to extremely low temperatures. Bull semen is generally frozen, while boar semen is used fresh because boar semen will not survive the freezing/thawing process.
  - 2) The basic unit for semen storage and shipment is an individual plastic straw containing just enough semen for a single insemination. Each straw is identified with the sire's name and registration number.
  - 3) Semen is frozen using liquid nitrogen or dry ice in an alcohol bath. Liquid nitrogen is maintained at -320°F in a semen tank, and the semen is stored there until used for breeding.
- h) General management practices
  - 1) Avoid breeding diseased or infected females.
  - 2) Have a veterinarian examine females that have been bred two or more times without conception.
  - 3) Wait at least 60 days after calving to breed cows back.
  - 4) Sows should be bred back 35-50 days after farrowing.
  - 5) All semen collection equipment should be clean and sterile.
- i) AI use in cattle
  - 1) Timing of insemination
    - (a) Generally, good conception rates for cattle herds are achieved by inseminating 12 hours after standing heat.
    - (b) Ovulation occurs 12 hours after estrous is completed; inseminate during ovulation.
  - 2) Insemination techniques
    - (a) After properly thawing the semen and loading the gun, the insemination gun is inserted with the tip upward at a 30° angle into the vagina. This angle keeps the gun from entering the urethra.
    - (b) After the gun is inserted into the vagina, place a gloved hand into the anus of the cow to direct the gun.
    - (c) Direct the gun tip through the vagina and into the cervix. Inserting the gun into and through the cervix can be difficult. If the opening of the cervix is

difficult to locate, straddle the cervix with the first two fingers of the gloved hand. Pin the cervix to the floor of the pelvis and locate the opening of the cervix with the thumb.

(d) Bring the tip of the gun up until it strikes the thumb. Insert the gun into and through the cervix by using light but steady forward pressure.

(e) The cervical channel consists of three cartilage-type rings. Hold the cervix with the gloved hand until the gun has worked through the three rings.

(f) After passing through the three rings of the cervical channel, the gun will slip forward with little resistance. When this happens, the tip of the gun will be in the uterine body. Since the uterine wall is thin, you should be able to feel the tip of the gun with the gloved hand.

(g) Insert the gun 2" into the cervix; otherwise, the semen is deposited in one uterine horn instead of both.

(h) Take about five seconds to deposit the semen slowly. Then, slowly pull the gun from the tract and clean the equipment.

j) AI in horses

1) Timing of insemination

(a) A mare's heat period lasts 2-10 days.

(b) The egg ovulates 1-2 days before the end of the heat period.

2) AI has become popular for use in horses, although fresh semen is required by many breed associations.

3) Normally, breed associations will not accept registration for foals conceived from frozen semen.

4) When AI is used, a syringe is attached by a rubber adapter to a disposable insemination tube.

5) Using a sterile sleeve glove, the inseminating tube is inserted directly into the vagina. Then the gloved fingers open the cervix and pass the rod into the uterus to place the semen directly into the uterus.

k) AI in sheep

1) AI is not widely used outside of research for sheep

2) In sheep, AI has taken longer to develop for the following reasons.

(a) There are no reliable indicators of the onset of heat in ewes.

(b) The ewe has a small and highly folded cervix, making it difficult to deposit semen directly into the uterus

(c) No suitable long-term storage method has been developed for ram semen.

(d) No method has been developed for identifying greatly superior sires.

(e) Conception rates from a single insemination are not high enough to produce an adequate lamb crop.

(f) The additional labor requirements for AI economically outweigh its benefits.

l) AI in swine

1) Timing of insemination

(a) The average length of the heat period is 2-3 days, but gilts' heat periods are usually slightly shorter than those of sows.

(b) Ovulation occurs 36-40 hours after the onset of heat. Even with daily observation, it is difficult to know precisely when the first standing heat occurs.

(c) Rule of thumb: Breeding should take place about 12 hours after observing heat and at 24-hour intervals for as long as the female will stand.

(d) Higher conception rates and larger litter sizes result from at least 2-3 services.

2) AI techniques

(a) Confine the female in a small pen.

(b) Put about 100cc of extended semen in a 4 oz. squeeze bottle with a cone-shaped tip.

        (c) Place a few drops of lubricant on the tip of the spirette. Insert the tip into the vulva, pointing it toward the backbone at a 45° angle to avoid the opening of the urethra. The cervix is usually 8-10" inside the vulva.
        (d) When the cervix is located, start rotating the catheter counterclockwise until it becomes "locked" into the cervix.
        (e) When the spirette is in place, connect the semen container and begin squeezing the semen through the spirette. If the semen starts to run out of the vulva, release pressure, wait a few moments, and start again.
        (f) When finished, remove the catheter and clean equipment.
    3) Problems of using frozen semen in swine
        (a) On the average, conception rates with frozen semen are 10-20 percent lower than those obtained with the use of freshly collected semen.
        (b) Also, litter sizes show a reduction of one pig per litter with the use of frozen semen.
m) AI in poultry (turkeys)
    1) Natural mating in broad-breasted turkeys generally results in low fertility rates.
    2) More than 90 percent of U.S. turkey breeders use AI with natural mating.
    3) The insemination is done with a syringe.

2. Ask the students what they know about estrous synchronization. Relate back to the motivation. When it would be used?

What is estrous synchronization and why is it important?

a) For AI and embryo transfer, it is important to have a large number of females in estrous at the same time--hence the term synchronization of estrous.
b) Importance of controlling estrous cycles
    1) Horse breeders often strive to breed their mares so that they foal shortly after January 1.
    2) Swine and sheep breeders try for two crops of offspring per year.
    3) In all species, it is desirable to shorten the period from the birth to the conception of the next offspring.
    4) With AI, breeding more females at one time cuts down on labor costs.

3. Show the students various products used for estrous synchronization.

What products are available for estrous synchronization?

a) Hormonal control of heat
    1) Progestogens - These compounds mimic the hormone progesterone, which controls the timing of estrous.
    2) Prostaglandins - These hormone-like substances cause blood levels of progesterone to fall, which induces estrous within 2-4 days.
b) Human Chorionic Gonadotropin (HCG) - This hormone, which has been used with some success in horse breeding, stimulates follicles to ovulate.
c) Synchro-Mate B® (SMB) - This is a trade name for an estrous synchronization product that was approved by the FDA in 1982. It contains Norgestomet®, a patented, potent, synthetic progestin, and estradiol valerate, a synthetic estrogen. SMB, which is used as an ear implant, is designed to cause cows and heifers to ovulate in a predictable period of time.
d) MGA (melengestrol acetate) - This synthetic progesterone suppresses heat in feedlot heifers. A drawback of MGA is that FDA approval is pending. Research has shown that a combination of MGA and prostaglandins can make estrous synchronization practical for cattle producers. Feeding MGA to heifers for 14 days and then following up 16-18 days

later with an injection of prostaglandin has resulted in a majority of the heifers coming into heat within five days.

4. Discuss the procedures performed to capitalize on genetically superior stock.

What is embryo transfer (ET) and when should it be utilized?

a) Embryo transfer (ET) is the placing of an embryo into the lumen of the oviduct or uterus.
b) History of ET
    1) In cattle ET was developed as a result of research done by Jim Rowson at Cambridge, England, in the early 1950s. The earliest work was done with sheep, then cattle and hogs.
    2) The first commercial transfers were done in the U.S. in the early 1970s.
c) Steps of ET for cattle
    1) Synchronization of estrous in donor and recipient cows
    2) Superovulation of the donor cow
    3) Breeding the donor cow
    4) Recovering the embryos from the donor cow 6-10 days after breeding
    5) Isolating and characterizing each embryo
    6) Transferring healthy embryos to the recipient cows
d) Recipient pregnancy determined in about 35 days
e) No genetic influence from recipient cows on the calves they carry
f) Advantages of ET
    1) Increases the reproductive potential of superior females
    2) Increases rate of genetic improvement in herd

5. Discuss what type of heifer calves a dairy producer wants. What if a procedure could be used to choose the sex of calves?

What is sexing semen and what is its economic importance?

a) Sexing semen determines if the semen contains the X or Y sex chromosome. If the semen contains the X chromosome, it will produce a female; if the semen contains the Y chromosome, it will produce a male.
b) Obtaining semen that has been sexed has great economic importance. Because the dairy producer has little use for most bull calves, the use of sexed semen to produce only females makes milk production more efficient. Swine producers could market more pork if they could only produce females because females grow faster than males. The opposite is true in beef cattle and sheep breeds, where more males are desired unless trying to produce replacement females.
c) Semen is sexed by the amount of DNA present on X and Y chromosomes. DNA content of the Y chromosome contains less DNA than the X chromosome.

6. Discuss the political and economic ramifications of cloning.

What is cloning?

a) Cloning of an animal is the production of an exact genetic copy.
b) Cloning is usually the result of splitting embryos, which produce genetically identical twins.

F. Other activities

1. Bring in a semen sample, either fresh or frozen, and view it under a microscope.

2. With materials for a semen test from the local veterinarian, perform a semen test in class.

3. Bring in a cow model or actual reproductive tract to demonstrate AI techniques.

4. Show the videos, *Embryo Transfer of Beef and Dairy Cattle* (13 min., AG video 177) and *Artificial Insemination of Beef and Dairy Cattle* (10 minutes, AG video 178), available from the Missouri Vocational Resource Center.

G. Conclusion

There are many management and technological techniques to control or manipulate an animal's reproductive cycle. All of the techniques need to be carefully analyzed before a producer decides whether to use any of them.

H. Competency

Describe how management and technology are utilized to affect the reproductive cycle.

Related Missouri Core Competencies and Key Skills

10C-4: Associate the roles of genetic variation and natural selection with change in organisms over time.

I. Answers to Evaluation

1. a, c, e (question worth 7 points)
2. a, d, f, g, i (question worth 10 points)
3. b, c (question worth 6 points)

4. Two of the following:
   a) Breed more females per day
   b) Shorten time period for rebreeding
   c) Helps provide two offspring crops a year in swine and sheep operations
   d) Helps mares foal close to Jan. 1

5. Two of the following:
   a) HCG (Human Chorionic Gonadotropin)
   b) SMB (Synchro-Mate B®)
   c) MGA (melengestrol acetate)

6. b
7. c
8. c
9. b

Name_______________

Lesson 6: Management and Technology in Reproduction

Date_______________

EVALUATION

Complete the following multiple answer questions.

1. Check the advantages of using artificial insemination in livestock.

___a. Reduction of reproductive diseases
___b. Reduction of respiratory disease
___c. Improved herd records
___d. Reduction of records kept
___e. Increased uniformity in herd
___f. Costs of semen and services exceed the value of progeny.
___g. Reduction in technical assistance in breeding program

2. Check the disadvantages of using artificial insemination in livestock.

___a. An increase in management skills
___b. A reduction in management skills
___c. Requires less time
___d. Requires more time
___e. A reduction in technical assistance in breeding program
___f. An increase in technical assistance in breeding program
___g. Subject to abuse, like improper labeling
___h. Reduces the occurrences of abuse
___i. Negative traits are perpetuated more rapidly.
___j. Reduces reproductive diseases

3. Check the advantages of embryo transfer.

___a. Increased calving rate of cows in herd
___b. Increased number of calves produced by superior female
___c. Increased rate of genetic improvement in herd
___d. Increased costs in breeding program
___e. Reduction in costs in breeding program
___f. Reduction in technical assistance in breeding program
___g. An increase in technical assistance in breeding program

Complete the following short answer questions.

4. What are two advantages to synchronizing estrous in animals?

a.

b.

5. List two products used for estrous synchronization.

   a.

   b.

Circle the letter that corresponds to the best answer.

6. Who is believed to have performed artificial insemination first?

   a. U.S. physiologist on cattle
   b. Arabian chief on his prized mare
   c. Farmer in rural England
   d. Ancient Turkish chief on his prized mare

7. Which ingredient is NOT included in semen extenders?

   a. Egg yolk
   b. Milk
   c. Mayonnaise
   d. All of the above

8. Sexing semen can be done because of the differing amounts of ___________ found in X and Y chromosomes.

   a. RNA
   b. Genes
   c. DNA
   d. Protein

9. How is cloning most commonly accomplished?

   a. Sexing semen
   b. Splitting embryos
   c. Splitting chromosomes
   d. Synchronizing estrous

UNIT IV - ANIMAL HEALTH

Lesson 1: Importance of Animal Health

Objective: The student will be able to understand the significance of animal health in livestock.

Study Questions

1. **Identify careers in animal health.**
2. **What is the economic importance of animal health?**
3. **How are drugs approved?**
4. **What are differences between population and individual medications?**
5. **What are government health regulations for movement of livestock interstate and intrastate?**

References

1. Student Reference

UNIT IV - ANIMAL HEALTH

Lesson 1: Importance of Animal Health

TEACHING PROCEDURES

A. Review

B. Motivation

What are the annual costs associated with animal health? What does animal health (or sickness) cost the average livestock producer? A whopping $11 billion is lost every year due to animal health problems, costing the average livestock producer 15 percent of annual cash receipts. Animal health is a large factor in the profit or loss of a livestock operation.

C. Assignment

D. Supervised study

E. Discussion

1. Ask students if they know what occupations are associated with livestock health and the educational background needed.

   Identify careers in animal health.

   a) Veterinarian - This occupation is involved with many aspects of livestock health. These include vaccinations, setting up health programs, deworming, curing sick or unhealthy animals, and detecting livestock diseases.
   b) Livestock producer - If they have the facilities, livestock producers do most of the on-farm vaccinations and treatments. Livestock producers also detect and observe diseases that affect their herds.
   c) Extension livestock health specialist - The Extension Service provides information about animal health programs. It provides health, sanitation, and prevention programs to producers.
   d) Animal health products representative - An animal health sales rep sells equipment, medicine, and necessary tools for administering on-farm vaccinations.
   e) Livestock health scientists - These scientists provide the latest research for new cures and detection of new diseases. They work at major universities, the USDA, and in industry.
   f) Animal health enforcement - People in this occupation enforce state or national regulations regarding animal transportation, quarantines, and health certificates. They also monitor for new livestock diseases to keep them from entering the country.

2. Ask students how animal health affects the profit or loss of a livestock operation. How could a livestock operation benefit from a health program or preventive measures?

   What is the economic importance of animal health?

   a) There are billions of dollars lost every year because of poor animal health. Approximately 15 percent of all producer cash receipts in a year are used to cover losses caused by diseases associated with animal health. This 15 percent translates into $11 billion lost annually.

b) The following items occur every year and determine profit or loss for a livestock producer.
   1) Approximately 12 percent of cows bred never calve due to diseases, which cause cows to abort the fetus, and general health or nutrition problems, which prevent or hinder conception.
   2) Approximately 6 percent of all calves die between birth and weaning because of general health and/or nutrition problems.
   3) About 10 percent of all calves are afflicted with scours; about 18 percent of dairy calves afflicted with scours die.
   4) Cow-calf operators spend approximately $26.95 per cow on disease prevention and death losses.
   5) Approximately 1.5 million cattle are lost in the feedlot due to general health problems, costing approximately $750 million.
   6) About one in 10 dairy females have breeding difficulties due to general health and nutritionally related problems.
   7) Approximately 40 percent of dairy cows are afflicted with a form of mastitis, which means $225 per year, per cow. (Mastitis-infected products cannot be used for human consumption.)
   8) About 5 percent of all ewes never lamb due to general health problems.
   9) Approximately 20 percent of all lambs die between birth and weaning because of general health and/or nutrition problems.
   10) Approximately 3 percent of all lambs on finishing rations die due to general health problems.
   11) Nearly 15 percent of all bred sows never farrow due to general health problems.
   12) Approximately one-fourth of all pigs die between birth and weaning.
   13) Approximately 50 percent of all bred mares abort or have weak foals due to general health problems. (This means that two mares are kept to produce one foal.)
   14) Approximately 6 percent of all foals die between birth and weaning due to general health problems.

c) There are also hidden costs that are not figured into the $11 billion lost yearly due to general health problems. These costs are reflected in poor meat quality, infected carcasses, added labor costs, retarded growth, inspector salaries, depreciation of infected land, and many other costs.

d) Some animal diseases can be transferred to humans by contact. There are strict regulations for these diseases because of the effects on humans. Here are some important animal diseases that can be transferred to humans.
   1) Lyme disease - Transmission of this disease is usually by a bite from a tick or by crushing an infected tick on broken skin. The increased risk to humans has been caused by more animals bringing the infected ticks closer to human habitations. Human cases of Lyme disease have been reported in the East coast, West coast, Great Lakes, and a few southern states. Human symptoms are skin lesions around the bite and arthritis in large joints. Sometimes symptoms do not appear until four years after contact. It is a curable disease, but there could be some permanent damage to a fetus and some neurological damage, which could be prevented by early detection.
   2) Brucellosis - Transmission of this disease can occur by contacting an aborted, stillborn fetus or placental tissues with cuts or scrapes on a person's hand. (It cannot penetrate normal skin.) It can also be transmitted by breathing aerosols containing the organism (such as in a packing plant) or consumption of unpasteurized dairy products. This organism cannot survive in dry conditions, in sunlight, or extremely hot conditions, but under favorable conditions it can survive for 3-4 months. Human symptoms are continued and intermittent occurrences of fever, headaches, profuse sweating and chills, depression, body aches, and weight

loss. Without proper treatment, these symptoms persist for several months. This disease cannot be transmitted to other members of the family by humans.

3) Rabies - Transmission of this disease occurs from a bite of a rabid animal. This natural disease occurs in animals to regulate overpopulation. In humans, 90 percent of the rabies cases are reported by wild animals, and the other 10 percent is from domesticated pets. This is why vaccination of pets is so vital. In humans, rabies is a curable disease if caught in time, but even the cure is very painful.

4) Salmonellosis - Transmission of this disease occurs through consumption of contaminated foods not properly stored or cooked. Salmonellosis can be found in pork, beef, poultry, eggs, milk, and even vegetables grown with infected fecal fertilizers. Symptoms occurring in humans from salmonellosis are intestinal infections, fever, abdominal cramps, vomiting, nausea, and diarrhea. Salmonellosis is a treatable disease by correcting dehydration and electrolyte imbalances.

5) Trichinosis - Transmission of this disease occurs by eating infested meat. Primary sources of trichinosis are under-cooked pork and wild animals, primarily carnivores such as bears. With proper cooking, this disease can be prevented. Symptoms are inflamed muscles or allergic reactions.

6) Cryptosporidiosis - Transmission of this disease occurs by ingesting contaminated food or water and by working around infected fecal material. Generally, people do not even know they are infected by cryptosporidiosis because the human body develops immunity to this disease. Diarrhea is the typical symptom in humans. This disease is more prominent in the population affected by Acquired Immune Deficiency Syndrome (AIDS) because their immune systems can no longer fight off disease.

7) Cowpox - Transmission occurs when a human comes in contact with an infected animal during the milking process. There appears to be a relationship between cowpox and smallpox immunizations. There are artificial immunizations for cowpox in humans. Human symptoms include sores on the skin. For dairy producers, the infections will usually appear on hands and arms, which are two areas that come into contact with the animal the most.

8) Brucellosis - Transmission occurs when a human comes in contact with an infected animal. This usually happens when disposing of dead, infected animals without knowledge of the cause of death. Infection in humans can also occur by ingesting contaminated dairy products. This disease is highly regulated and controlled by state institutions because of its contagious nature to humans.

9) Ringworm - Transmission occurs when a human comes in contact with the fungus through an infected animal or infected quarters where the animal has been. Human symptoms usually appear as discolored spots on the skin. This fungus can live up to 18 months on fence posts, animal brushed, or curry combs.

3. It costs approximately $3 million for a drug to be approved for human use. Ask students how drugs are approved for livestock and the procedure used for drug authorization.

How are drugs approved?

a) Development of new drugs

1) A new drug begins when a manufacturing company sees the need for it and has the research capabilities for developing it. Generally, a new drug is developed through the discovery of a new compound that could be useful in animal health. Research and development must prove that the compound is effective, safe, and convenient to use.

2) Research and development of a new drug is expensive, time-consuming, and exacting. In 1988, animal health institutions spent $340 million on research and development of new drugs.

b) Approval process for new drugs

1) Discovery - The first step in drug approval is the discovery of a new compound that is suitable for animal health. This discovery could be accidental or discovered through research and development.

2) Preliminary trials - Once a compound is found helpful in animal health, it goes through some preliminary trials. Three questions must be answered before intense development procedures take place.

(a) Does the new drug have any undesirable traits? What is the potential activity of the new compound?

(b) What are the estimated costs for research and the anticipated demand for this new compound?

(c) Can it be confirmed that the new compound will do what it is supposed to do?

3) Pre-clinical trials - Pre-clinical trials target animals on which the drug could be used. These trials are usually done in a laboratory setting on lab animals. Exaggerated dosages are given to determine the effects. If the manufacturer is still convinced of the effectiveness of the compound, appropriate agencies are notified.

4) INAD/EUP notification - INAD (Investigational New Animal Drug) is the branch of the FDA that is notified. If the new compound is a pesticide, an EUP (Experimental Use Permit) is the notification to the EPA. These applications show the results of safety, effectiveness, and toxicity studies of the compound, as well as plans for continued testing and small amounts of the compound. After receiving an INAD or EUP file number, the manufacturer makes the final decision to go ahead with clinical testing.

5) Clinical trials - Clinical trials consist of full-scale field trials. At this point, the manufacturer has a sizable investment in the compound and determines if it will be economical to continue research. Field trials are done on animals targeted for usage of the drug. These studies consist of toxicity levels, dosage, residue studies, effectiveness, and blind studies. In blind studies, animals receive the compound in such a way that researchers are not aware of which animals received it. The data is evaluated to show the effectiveness of the compound.

6) Drug and pesticide approval - Here, a manufacturer applies to federal agencies for the right to produce the new drug. The manufacturer files for a NADA (New Animal Drug Application) or a pesticide permit. The typical NADA application would fill an average encyclopedia volume. It reveals the results of environmental effects, safety to users, animals, and consumers.

7) Monitoring - Once the drug or pesticide is marketed, the manufacturer must report findings back to federal agencies every six months for the first year, as well as yearly for the remaining years the drug or pesticide is produced. Further monitoring is done by veterinarians across the country, who report on any adverse conditions that occur through usage of the drug or pesticide.

4. Why is it important to know the differences between population and individual medications?

What are differences between population and individual medications?

a) Individual medications are administered to one individual animal. The label verifies the dosage per individual, which is justified by body weight, age, or type of production.

b) Individual medications can be over-the-counter drugs, extra label drugs, or prescription drugs administered by veterinarians.

c) Population medications are mixed with feed, a complete feed, or fed by themselves. These drugs are usually classified as feed additives and administered for a population of animals.

d) To deworm a pen of finished cattle, mix the dewormer in the feed and medicate the whole population. Population medications are usually mixed into feed.

e) As mentioned previously, individual medications are approved after going through a long, expensive process.

f) Population medications and feed additives go through a different process for approval than individual medications. However, both have federal agencies regulating the approval of these medications.

5. Ask students if they know the legalities of transporting animals in state and out of state.

What are government health regulations for movement of livestock interstate and intrastate?

a) Intrastate regulations
  1) It is a "buyer beware" market when purchasing and transporting livestock within the state of Missouri. Livestock can be transported anywhere in the state without a health certificate.
  2) A buyer can request health papers, but the seller does not have to provide them.
  3) If a producer buys livestock at an auction, some health tests will be run at that sale barn. The actual types of tests are determined by the operator of the sale barn.
  4) Most purebred and crossbred operations have health papers on all stock in their operation.
  5) Most other states have similar intrastate regulations.

b) Interstate regulations
  1) Each state has different regulations on interstate transportation of livestock. If a Missouri producer sells cattle to a Kansas producer, the seller is responsible for finding out Kansas health regulations so the cattle can be transported legally. Then, a veterinarian can run the required health tests. If the cattle pass the required tests, a health certificate is issued for that group of cattle that stays with them through the entire process of interstate transportation.
  2) A health certificate is not necessary for each state that the cattle pass through--just the state of destination. To be safe, however, contact each state veterinarian's office.

c) Federal regulations
  1) Livestock cannot be transported on a rail car for more than 28 hours without rest, food, and water. This rest period must last for five hours before being loaded back up for transportation.
  2) Livestock traveling by truck or trailer cannot be transported for more than 24 hours without rest, food, and water. The break must last at least five hours before the animals are loaded up again.

F. Other activities

1. Invite personnel from the state Dept. of Agriculture to discuss the rules and regulations of livestock transportation.

2. If a speaker phone is available, demonstrate the Voice Response Service coordinated by the USDA's Center for Epidemiology and Animal Health. Using a touchtone phone, call 800/545-USDA (8732) to connect with the service, which supplies information on state regulations (including transportation), emergency notices, animal care, etc.

3. Show the video, *Cattlemen Care About Animal Welfare* (10 minutes, AG video 188), available from the Missouri Vocational Resource Center.

G. Conclusion

It is important to understand the economic importance of animal health and the costs associated with it. As a consumer, it is vital to understand diseases associated with eating animal products and the possible human effects. Consumers and livestock producers should understand the importance of drugs and how they are approved for animal health.

H. Competency

Identify the importance of animal health in livestock.

I. Answers to Evaluation

1. 11 billion, 15
2. Hidden
3. Brucellosis
4. Salmonellosis
5. Trichinosis
6. Intrastate
7. New Animal Drug Application
8. Experimental Use Permit
9. Population
10. a, c-h (question worth eight points)
11. b, c, d, f, g (question worth eight points)
12. b, e (question worth five points)
13. a-f (question worth six points)

UNIT IV - ANIMAL HEALTH Name______________

Lesson 1: Importance of Animal Health Date______________

EVALUATION

Fill in the blank with the best answer.

1. Animal health problems cost livestock producers $____________ annually, which is ______ percent of cash receipts per livestock producer.

2. Infected carcasses, poor meat quality, additional labor costs, and depreciation of infected land are called ____________ costs, which are not figured in annual health problems.

3. The disease, ________________ , is transmitted to humans by contact with an infected fetus or placental tissues. Symptoms are fever, headaches, profuse sweating and chills, depression, and body aches.

4. Improper storage and cooking techniques can transmit ________________ to humans. Symptoms are intestinal infections, fever, vomiting, nausea, and abdominal cramps.

5. The disease, ________________ , is transmitted to humans by ingesting contaminated meat, mainly pork. Symptoms are inflamed muscles or allergic reactions.

6. The transportation of livestock within a state, which does not require a health certificate, is called ________________ transportation.

8. EUP stands for ______________________________ .

9. A feed additive is considered to be a ________________ medication.

Complete the following multiple answer questions.

10. Check the appropriate steps in drug approval of animal health products.

____ a. Monitoring
____ b. Scheduling
____ c. Discovery
____ d. Clinical trials
____ e. Pre-clinical trials
____ f. Drug and pesticide approval
____ g. INAD/EUP notification
____ h. Preliminary trials

11. Check the factors that are true about individual medications.

____ a. Can be administered through mixing of bulk feeds
____ b. Can be prescribed by veterinarians
____ c. Can be purchased over the counter
____ d. Administered by specific dosages
____ e. Can be administered through the water supply
____ f. Are administered to individual animals
____ g. Are approved by the FDA
____ h. Go through the same approval procedures as population medications

12. Check the requirements needed for interstate transportation of livestock.

____ a. A health certificate for every state the livestock passes through
____ b. A health certificate for only the state of destination
____ c. The rest period for transported livestock must be at least three hours long.
____ d. Livestock transported by rail car cannot travel more than 30 hours without a rest.
____ e. Livestock transported by truck or trailer cannot travel more than 24 hours without a rest.

13. Check the careers that are associated with animal health.

____ a. Veterinarian
____ b. Livestock producer
____ c. Extension livestock health specialist
____ d. Animal health enforcement
____ e. Livestock health scientist
____ f. Animal health products representative

UNIT IV - ANIMAL HEALTH

Lesson 2: Immune System of Livestock

Objective: The student will be able to describe aspects of the immune system of livestock.

Study Questions

1. **What are the causes of different types of diseases in livestock?**
2. **What are the different types of immunity?**
3. **What are the different types of immunizing agents, and how do they work?**
4. **What is an antibiotic, and how does it work?**

References

1. Student Reference

Lesson 2: Immune System of Livestock

TEACHING PROCEDURES

A. Review

Review the previous lesson.

B. Motivation

Bring in different types of vaccines and talk about what they are used for and how they work.

C. Assignment

D. Supervised study

E. Discussion

1. A disease is any condition that detracts or interferes with an animal's well-being. Discuss ways producers can control and prevent diseases within their herds.

What are the causes of different types of diseases in livestock?

a) Noninfectious diseases - not caused by infectious organisms
    1) Nutritional diseases
        (a) These can occur when the animal receives too little or too much of a particular nutrient in the diet.
        (b) A deficiency of certain vitamins and minerals can produce a variety of symptoms, such as poor growth, weak bones, weak muscles, poor eyesight, and a decreased resistance to other diseases.
    2) Metabolic diseases
        (a) Can occur when the animal's organs do not function correctly
        (b) Can happen when the animal undergoes major changes in its life
        EXAMPLE: Milk fever at parturition
    3) Toxic diseases
        (a) Exposure to poisonous materials cause toxic diseases.
        (b) Common livestock poisonings involve farm chemicals (such as insecticides and herbicides) and automotive products (batteries, antifreeze).
        (c) Some poisons form when mold grows on grain or hay that is used for feed.
        (d) Some plants are poisonous.
    4) Injury or trauma
        (a) Lightning strikes
        (b) Lameness after foot injury on rough or rocky surfaces
        (c) Predator animals (such as wolves and coyotes)
    5) Congenital diseases (present at birth)
        (a) These are often caused by faulty development of the fetus inside the mother's uterus.
        (b) Some examples are cleft palate (a hole in the roof of the mouth) and ventricular septal defect (an abnormal opening between two heart chambers).

6) Genetic diseases (inherited from parents)
   (a) Symptoms of genetic diseases may or may not be present at birth.
   (b) One example is porcine stress syndrome.

b) Infectious diseases
   1) Infectious diseases are caused by other living organisms (pathogens) that infect and cause disease.
   2) The way that these organisms cause disease varies.
      (a) Killing the cells or tissues that they infect
      (b) Producing toxins or poisons, which have an adverse effect on the animal's body
      (c) Bacteria and viruses (most common)
         (1) Bacteria are microscopic, single-celled organisms.
         (2) Bacteria are very common; most are harmless, and some may even be beneficial.
         (3) However, a few bacteria are pathogenic and can be harmful to the animal. Pathogenic bacteria require moisture, warmth, and nutrients to grow and multiply. An animal's body provides all of these requirements.
         (4) Bacteria cause disease when they grow in places where they are not supposed to grow or when they produce by-products that are harmful to the animal's body. Some examples of bacterial diseases are *E coli* diarrhea in calves and piglets, blackleg in calves, and erysipelas in pigs.
         (5) Viruses are extremely small particles that can only be seen by the most powerful electron microscopes.
         (6) Viruses cannot grow or reproduce unless they infect the cells of another organism. Some examples of viral diseases in livestock are infectious bovine rhinotracheitis (IBR or red nose) in cattle and transmissible gastroenteritis (TGE) diarrhea in pigs.
      (d) Fungi and protozoa
         (1) Fungi are usually more complex in form than bacteria.
         (2) Fungi can consist of more than one cell with different functions.
         (3) Most familiar fungi (mushrooms, molds) do not infect animals. However, some diseases, such as ringworm and thrush, are caused by fungi, which can infect animals.
         (4) Protozoa are single-celled animals. As with bacteria, most protozoa are harmless and some are even beneficial (helping in digestion, for example). Other kinds of protozoa, such as coccidia, infect animals and cause disease.

2. Animals are faced with exposure to potentially pathogenic organisms every day and usually do not get sick from these exposures. Fortunately, animals have mechanisms to ward off these threats to their health: natural and acquired immunity. Discuss reasons that certain livestock species are resistant to diseases, while others are not.

What are the different types of immunity?

a) Natural, physical barriers protect animals from infection with disease-causing organisms or trap pathogens before they can infect the body.
   1) Skin
   2) Mucus
   3) Tears

b) Certain body cells in the body examine everything they contact to determine whether or not it belongs there.
  1) If found, these cells notify the immune system to produce antibodies against that particular pathogen.
  2) Antibodies are protein molecules that bind with the pathogen and help other cells in the body eliminate it.

c) Active immunity is the process of producing antibodies against a pathogen by a natural exposure to that pathogen or by vaccination.

d) In passive immunity, animals may also receive antibodies that another animal has made (e.g., colostrum or blood serum).

3. Vaccines are basically a modified form of the pathogen that will not cause disease. Discuss what vaccinations are used for and how the students think they work. Ask the students about diseases for which they have been vaccinated. How do producers prevent the spread of disease throughout herds?

What are the different types of immunizing agents, and how do they work?

a) Modified live vaccines
  1) Live viruses or bacteria that have been changed so that they will not produce disease
  2) Very effective at stimulating the animal's immune system

b) Killed vaccines
  1) Viruses or bacteria that have been killed, often by treatment with heat or chemicals
  2) Sometimes called bacterins

c) Toxoids
  1) A changed form of toxin or poison that will help the animal produce antibodies against the toxin
  2) Tetanus vaccine for horses and sheep

d) Antisera and antitoxins (passive immunity)
  1) Antibodies to specific pathogens and toxins that have been formed in the blood serum of another animal
  2) Quick protection against certain diseases, but not as long lasting as the active immunity stimulated by vaccines and toxoids

4. Discuss what antibiotics are used for and how the students think they work.

What is an antibiotic, and how does it work?

a) Antibiotics are compounds produced by microorganisms (often fungi) that either kill or inhibit the growth of other bacteria or fungi.

b) They are often given either by mouth or by injection.

c) Many different antibiotics are available.
EXAMPLES: Penicillin and tetracycline

d) Some pathogens are resistant to the effects of certain antibiotics.

e) Antibiotics have no effect on viruses.

F. Other activities

1. Look at bacteria under the microscope.

2. Ask the local veterinarian or school nurse to talk to the class about vaccinations and antibiotics.

G. Conclusion

Animal diseases are the world's oldest and toughest enemies. Losses from animal diseases and parasites cost producers and the economy billions of dollars. Much of this waste could be reduced by disease-prevention programs.

H. Competency

Describe the aspects of the immune system of domestic livestock.

Related Missouri Core Competencies and Key Skills

10C-2: Hypothesize how genetic resistance develops from continued exposure to pesticides or antibiotics.

I. Answers to Evaluation

1. c
2. a
3. d
4. d
5. a
6. a
7. b
8. d-f (question worth eight points)

UNIT IV - ANIMAL HEALTH Name_______________

Lesson 2: Immune System of Livestock Date_______________

EVALUATION

Circle the letter that corresponds to the best answer.

1. Which type of vaccine lasts the shortest period of time?

   a. Modified live vaccine
   b. Toxoid
   c. Antiserum and antitoxin
   d. Killed vaccine

2. Antibiotics have no effect on which of the following?

   a. Viruses
   b. Bacteria
   c. Fungi
   d. Protozoa

3. Which is true of antibiotics?

   a. Produced by microorganisms (often bacteria)
   b. Never given by mouth
   c. Few kinds are available.
   d. Effects can be resisted by some pathogens.

4. Feeding colostrum to newborn animals is a form of which type of immunity?

   a. Active
   b. Required
   c. Natural
   d. Passive
   e. Individual

5. From what do antibiotics originate?

   a. Living microorganisms
   b. Dead microorganisms
   c. Toxic materials
   d. Metabolic materials

6. What is produced by the tissues in reaction to disease?

   a. Antibodies
   b. Antiserum
   c. Bacterins
   d. Toxoids

247

7. Which is produced in the blood serum of another animal?

a. Modified live vaccines
b. Antiserum and antitoxins
c. Killed vaccines
d. Toxoids

Complete the following multiple answer question.

8. Check natural defense mechanisms animals use to fend off infectious diseases.

____ a. Vaccines
____ b. Toxoids
____ c. Bacteria
____ d. Skin
____ e. Mucus
____ f. Antibodies
____ g. Hair
____ h. Antibiotics

UNIT IV - ANIMAL HEALTH

Lesson 3: Respiratory Diseases Affecting Livestock

Objective: The student will be able to understand and describe the diseases of the respiratory system affecting livestock.

Study Questions

1. **What are the major swine respiratory diseases, their symptoms, and treatments?**
2. **What are the major cattle respiratory diseases, their symptoms, and treatments?**
3. **What are the major equine respiratory diseases, their symptoms, and treatments?**

References

1. Student Reference
2. Activity Sheet
   a) AS 3.1: Respiratory Diseases

UNIT IV - ANIMAL HEALTH

Lesson 3: Respiratory Diseases Affecting Livestock

TEACHING PROCEDURES

A. Review

Review previous lesson on aspects of the immune system of domestic livestock.

B. Motivation

Why is it important for non-veterinarians to know respiratory diseases of livestock? Someone in livestock production or a related occupation should understand the effects of respiratory diseases on a single operation and the entire livestock industry. To prevent diseases from spreading throughout the herd and causing extreme losses, a producer must be able to recognize the symptoms of these diseases. Everybody should understand how outside influences can trigger a respiratory infection within a herd. The effects of stress lead to many infections in livestock. Like humans, animals under stress are more likely to be invaded by viruses or bacteria because their bodies are run down.

C. Assignment

D. Supervised study

E. Discussion

1. See if students can come up with some major respiratory diseases in swine.

What are the major swine respiratory diseases, their symptoms, and treatments?

a) Atrophic rhinitis
  1) Description - Atrophic rhinitis is a highly transmissible disease in swine caused by bacteria *(Bordetella* and *Pasteurella).* It causes distortion of the nasal passages. Infected swine have lower production levels and are more susceptible to other respiratory diseases. Atrophic rhinitis is not a fatal disease--just an unwanted disease. It is transmitted as an aerosol from an infected hog to a noninfected one. Other carriers are dogs, cats, rabbits, mice, turkeys, horses, and humans.
  2) Symptoms - Sneezing and sniffling are the most common symptoms in swine and are good early detections for the disease. Coughing and snorting are other symptoms of atrophic rhinitis. Inflammation of nose membranes is also a good indication of this disease. As the disease matures, the shape of the nose becomes deformed. The nose turns to one side or the other by as much as 45 degrees.
  3) Prevention - A producer must monitor the contact with outside animals. A producer must also correct environmental deficiencies in sanitation, temperature, humidity, and ventilation. Control dust, drafts, excessive ammonia, and over-crowding.
  4) Treatments - A producer can protect against *Bordetella* and *Pasteurella* organisms by medicating feed with sulfamethazine or oxytetracycline.

b) Mycoplasma pneumonia
  1) Description - Transmission of the disease occurs easily by contact. Other means of transmission are: infected clothing, dust, and wind transmission from shed to shed. Young pigs are most susceptible at 3-9 months. Pigs showing symptoms of this disease that appear to have recovered still become carriers of the disease. Also, symptoms can reappear if pigs become stressed. The mortality rates for

Mycoplasma pneumonia are relatively low, but secondary infections can increase death, so treatment is important in controlling the disease.

2) Symptoms - A dry, hacking, repetitive cough in young pigs are typical chronic symptoms of mycoplasma pneumonia. Infected pigs remain alert and still have a healthy appetite but have reduced growth rates, weights, and feed efficiency. Acute cases cough and pant and appear to have a fever, little appetite, and a staggering gait.

3) Prevention - Isolate and observe outside animals brought into the herd. This also applies to animals that are suspected to be infected. After working with infected animals, change and wash clothing worn during the process. Make sure there is appropriate feed and water so animals do not come under further stress. There are vaccines available to prevent this disease.

4) Treatments - There are a wide variety of antibiotics and feed additives to treat animals. It is recommended that different medications be used so the disease does not become resistant to one medication. Keep infected animals isolated in a dry, warm, well-ventilated area with appropriate feed and water.

c) *Pasteurella* pneumonia

1) Description - Like most respiratory diseases, *Pasteurella* pneumonia spreads in the aerosol form. Younger pigs are generally affected by the disease. Pigs of 8-24 weeks are most susceptible to *Pasteurella* pneumonia. Mortality rates are high if effective treatments are not administered. Death can occur as quickly as 5-10 days if not treated.

2) Symptoms - Fever, coughing, depression, mouth breathing, and labored abdominal movements are all typical acute symptoms of *Pasteurella* pneumonia. Chronic symptoms are intermittent coughing and signs of unthriftiness.

3) Prevention - Chilling, dusty conditions, poor nutrition, a change in ration, overcrowding, poor ventilation, and poor hygiene can trigger *Pasteurella* pneumonia. All these factors are signs of poor management.

4) Treatment - Infected animals can be treated with antibiotics through injections. Other animals that shared the same airspace can be treated with feed or water additives for 5-7 days. Like most respiratory diseases, *Pasteurella* pneumonia is a treatable and preventable disease if caught early enough.

d) Haemophilus pneumonia

1) Description - Weaning-age pigs are the most susceptible to Haemophilus pneumonia, but all ages of swine can be infected. Like most respiratory diseases, Haemophilus pneumonia is transmitted in the aerosol form. Mortality rates are as high as 60 percent if it is not treated quickly.

2) Symptoms - Severe respiratory distress, severe abdominal respiration, and bloodstained discharge from the nose and mouth are acute symptoms of Haemophilus pneumonia. This particular disease hits fast. Some infected pigs die within a few hours or in a couple of days. A true, fatal sign of this disease is when pigs lie down and are not inclined to move. Chronic cases are usually non-fatal, and pigs show signs of ill thrift, persistent cough, fever, and respiratory distress.

3) Prevention - A good preventive measure for Haemophilus pneumonia is to provide well-ventilated, clean, and properly spaced conditions. Infected pigs that have been treated might develop immunity to future outbreaks of this disease. Also, sows that have been infected and treated might pass immunity to the offspring by colostrum in the milk. It is also a good idea to isolate outside animals for a while to observe for symptoms.

4) Treatment - There are several available antibiotics used to treat secondary infections in pigs. Treatments come in the forms of feed or water additives and injections. It is very treatable if infected animals can be isolated quickly to prevent spreading of the disease to the herd.

e) *Salmonella choleraesuis*

1) Description - This organism enters the body orally, multiplies in the intestinal tract, crosses the intestinal wall, and spreads throughout the rest of the animal. It undergoes its most rapid growth and does the most damage in the lungs. This disease is usually seen in pigs from 40 pounds to finish weight but can occur in any aged pig.

2) Symptoms - The most common sign is sudden death in pigs that had been doing very well. If observation is frequent enough and detailed enough, one may actually see pigs become somewhat listless, experience difficulty breathing, and progress rapidly to severe respiratory difficulty and death. Animals dying from this disease often have purplish discoloration of the ears, belly, and/or feet and lower legs.

3) Prevention - Sanitation efforts are extremely cost-effective in preventing this disease because it is transmitted through the feces. Minimizing stress also helps in prevention; many hogs can be carriers but yet will never have problems if they are not stressed enough to lower their resistance. Stressors include overcrowding, drastic temperature fluctuations, feed/water shortages, movement, mixing, etc. While preventive antibiotic therapy and/or use of vaccines can offer some benefit, their long-range cost-benefit ratio will not be as great as improved sanitation and decreased stress.

4) Treatment - In an outbreak, water medication and individual injections with appropriate antibiotics are the best approaches. Antibiotic selection needs to be based on cultures tested in a laboratory and known successes in the local region.

f) Porcine Reproductive and Respiratory Syndrome (PRRS)

1) Description - This disease was first diagnosed in the mid-1980s. It is caused by a type of virus, which produces two known syndromes: a reproductive herd problem and a respiratory syndrome found primarily in pigs younger than 10 weeks old. The virus is usually transmitted through pig-to-pig contact. The virus is shed from the respiratory system, in the feces, and in the semen. There may be some transmission through the air.

2) Symptoms - PRRS presents itself primarily as a difficulty in breathing that often progresses to a deep cough, rough hair coat, poor growth, and an increase in secondary bacterial infections of the respiratory tract (e.g., *Pasteurella, Bordetella, Haemophilus, Streptococcus, Actinobacillus, Salmonella*, etc.). Death losses can often be as high as 25 percent within a group of pigs. Deaths are from secondary infections, not from the virus itself.

3) Prevention - The best prevention is maintaining a negative herd through tight biosecurity and obtaining replacement stock from a known negative herd. In addition, making use of all-in, all-out pig flows will help prevent the disease from reaching its most severe level. A commercially approved vaccine is available to help prevent the disease. It is approved for use in pigs that are 3-16 weeks of age.

4) Treatment - There is no treatment for the viral disease itself, so treatment efforts are aimed at secondary invaders that complicate and worsen the disease.

2. See if students can come up with some major respiratory diseases in cattle.

What are the major cattle respiratory diseases, their symptoms, and treatments?

a) Infectious Bovine Rhinotracheitis or "Red Nose" (IBR)

1) Description - This disease is transmitted by infected droplets that are spread by coughing and by nose-to-nose contact. Also, the disease can be spread venereally or by contaminated examination instruments. The virus can be found in infected tissues of aborted fetuses and in nasal or ocular (eye) fluids of infected animals, but rarely in blood. All ages and breeds of cattle are susceptible. IBR can

be fatal, but generally it only causes reproductive and respiratory problems to appear.

2) Symptoms - Symptoms are: open-mouth breathing, fever, large amounts of nasal discharge, and a fiery red nose. Symptoms such as depression, a lack of appetite, labored breathing, and coughing are prominent signs of IBR.

3) Prevention - IBR is so widespread it is hard to find a herd that does not have a carrier. Prevention is usually by vaccines and natural immunity. Less-confined environments reduce chances of an outbreak of IBR. Cattle can develop a natural immunity to this disease, but vaccinations prevent secondary infection.

4) Treatment - Antibiotics on severely affected animals helps suppress secondary infections, but antibiotics have little to no effect on the virus.

b) *Pasteurella* infections

1) Description - *Pasteurella* is a bacterial infection usually affecting feedlot or grouped, well-confined animals. This disease can affect all ages of cattle. A *Pasteurella* infection can be spread by droplets in the air, contact, coughing, or feeding equipment. This is a very treatable disease, especially in older animals. More severe and fatal cases hit the younger population.

2) Symptoms - Infected animals show signs of fever, persistent cough, discharge from the nose, rapid respiration, and sometimes diarrhea. Other symptoms are depression, lowering of the head, and sometimes eye discharge.

3) Prevention - Prevention depends largely on good management practices for stress prevention. Avoid quick ration changes, overcrowding, outside infections, and stressful movement of cattle.

4) Treatment - It is essential to keep isolated animals in a dry, warm, well-ventilated area. Antibiotics and the proper environment will speed the recovery process.

c) Bovine Respiratory Syncytial Virus (BRSV)

1) Description - BRSV usually targets the younger population of cattle in feedlots. Transmission of the disease occurs through the aerosol form or contact. Generally, weaning-age stock is infected the heaviest with the disease. Cattle of 6-9 months are most susceptible in feedlot conditions and have very high mortality rates. Older cattle can be affected with the disease, but not as fatally.

2) Symptoms - Coughing, depression, large quantities of nasal discharge, open mouth breathing, and frothing are true indications of BRSV. Fever, severe respiratory distress, and extension of the neck are other symptoms. July through October seem to have the highest number of cases. Once it becomes colder, the cases decline in number.

3) Prevention - Weaning-age stock in feedlot conditions are the most susceptible population. Isolate suspected animals as quickly as possible to reduce the spread of the disease. Sudden changes in diet or water supply will induce extra stress on the animals.

4) Treatment - Antihistamines and vitamins are used for treating infected animals with BRSV. Revaccinating for IBR has also been effective against BRSV. Remember, isolating infected animals and providing proper environmental conditions will aid in treating these animals.

d) Bovine Virus Diarrhea (BVD)

1) Description - BVD generally occurs by contact, infected urine, or by the aerosol form. All populations of cattle can be affected, but the most susceptible animals are 6-18 months old. More cases of this disease are reported during the winter and early spring months. A persistently infected bull can spread the disease through his semen to uninfected cows and their fetuses.

2) Symptoms - Acute cases generally show signs of a fever, depression, weakness, oral and nasal lesions, dehydration, diarrhea, lameness, nasal discharge, and increased salivation. In acute cases, fatalities usually occur 3-4 days after infection. Since the disease is carried through the bloodstream, a pregnant cow

can abort her fetus. Chronic cases can linger for 2-6 months and sometimes past a year. These chronic cases remain carriers for the disease.

        3) Prevention - Stress, hormonal changes associated with puberty, and the enhancement of an already existing virus can trigger the infection of BVD.
        4) Treatment - Vaccinations control the spread of the disease to uninfected animals. The infected animals usually die, and the ones that survive should be destroyed.

3. See if students can come up with some major equine respiratory diseases. Explain that horses, donkeys, zebras and mules belong to the equine family, just as beef and dairy cattle are in the bovine family.

    What are the major equine respiratory diseases, their symptoms, and treatments?

    a) Strangles
        1) Description - Due to bacterial *Streptococcus equi*, younger horses are particularly susceptible to strangles, but any horse that has not suffered from the disease previously will also be susceptible. Infection spreads through inhaling or ingesting droplets breathed or coughed from infected animals. This very contagious bacterial disease affects the upper respiratory tract in horses. This is a very treatable disease, but it can also be fatal. Strangles spreads quickly.
        2) Symptoms - Animals infected by strangles have a very high fever, coughing, snorting, and thick mucus discharge. The throat, pharynx, and larynx become inflamed, and the animals have difficulty swallowing. Often when food or water is swallowed, these substances are regurgitated back through the nostrils.
        3) Prevention - Isolating infected animals helps control spreading of the disease. Cold, poorly ventilated stables and very confined conditions can lead to an outbreak. Overworked animals and severe weather conditions can also increase the chances for this disease. Since humans can also spread the disease, disinfect all clothing after working with infected animals.
        4) Treatment - There are several antibiotics available for treatment; early treatment will help prevent abscesses.
    b) Rhinopneumonitis
        1) Description - Rhinopneumonitis is a viral disease transmitted by droplets in the aerosol form. The virus circulates through the bloodstream and localizes in the respiratory tract. The disease is usually concentrated to younger horses. Donkeys and horses are the only species that have been reported to be infected naturally. Rhinopneumonitis is a treatable disease but is known for aborting foals.
        2) Symptoms - Generally an outbreak occurs in the autumn and winter months and is usually mistaken for a cold. Horses infected by the disease will have a fever, congestion, and nasal discharge. Sometimes coughing and loss of appetite can be symptoms. This disease is very difficult for a rancher to diagnosis without the help of a licensed veterinarian.
        3) Prevention - Isolate infected animals from the herd. A rancher could reduce outbreaks by not confining animals in tight, poorly ventilated areas. There are vaccinations, but they are not proven 100 percent effective.
        4) Treatment - There are a number of antibiotics that can be used to control secondary infections. Certain antibiotics are used strictly for nursing mares, while others are used for gestating mares.
    c) Equine influenza
        1) Description - Equine influenza is an acute, highly infectious, viral disease in horses. The disease is transmitted in the aerosol form and has very high mortality and abortion rates. Outbreaks usually occur when moving or grouping horses. This disease is so infectious that horse shows require health papers stating the animal has been vaccinated against the disease.

2) Symptoms - Symptoms of Equine influenza are very similar to other respiratory diseases in horses. These symptoms include: fever, nasal discharge, depression, weakness, dehydration, and loss of appetite. This disease is fatal but can be treated if caught quickly. Death and aborted foals are extreme symptoms of Equine influenza.

3) Prevention - Ranchers and owners must be aware of this disease when grouping and moving animals or introducing outside animals. There are vaccinations to prevent this disease.

4) Treatment - Isolating infected horses is important in treating them and preventing the spread of the disease throughout the herd. Keeping the infected animal in a dry, warm, well-ventilated area will also help. There are antibiotics available to prevent secondary infections for infected animals.

F. Other activities

1. A visit from a licensed veterinarian would help students apply this material. A veterinarian should have real-life examples to use so the students can better understand these diseases. The interaction with students might shed some light on other respiratory diseases.

2. As students work through the lesson, have them fill out Activity Sheet 3.1 as they learn about the respiratory diseases for each class of livestock. This will help students see the differences and similarities in the diseases.

G. Conclusion

It is important for livestock producers and others in the livestock health field to have a good knowledge base of respiratory diseases, their symptoms, and treatments. The producer is the first step in the prevention, treatment, and detection of any respiratory diseases because they come into contact with the animals more often than any other person. Everyday observations of livestock are critical for prevention, treatment, and detection of respiratory diseases.

H. Competency

Describe the diseases of the respiratory system affecting livestock.

I. Answers to Evaluation

1. Antibiotics
2. Vaccines
3. Atrophic rhinitis
4. Strangles
5. Isolate
6. a-h (question worth eight points)
7. a, c, d, f, i, j (question worth 10 points)
8. a-e, i, j (question worth 10 points)

J. Answers to Activity Sheet

AS 3.1 (Answers may vary but should be similar to the following.)

Swine	What is it?	Mode of infection	Symptoms	Prevention	Treatment
Atrophic rhinitis	Disease that causes distortion of the nasal passages	Hog-to-hog (aerosol) or from dogs, cats, rabbits, mice, turkeys, horses, humans	Sneezing, sniffling, coughing, snorting, inflammation of nose membranes	Monitoring contact with outside animals; controlling sanitation, temperature, humidity, ventilation, dust, drafts, extra ammonia, overcrowding	Isolating infected animals; medicating feed for uninfected animals
Mycoplasma pneumonia	Affects pigs 3-9 mos.	Contact; infected clothing, dust, and wind	Dry, hacking, repetitive cough; reduced growth rates, weights and feed efficiency **Acute cases:** coughing, panting, fever, reduced appetite, staggering gait	Isolating and observing outside animals entering the herd; always changing and washing clothes after being around infected pigs; providing plenty of food and water	Antibiotics; feed additives; keeping infected animals in dry, warm, well-ventilated area with enough feed and water
Pasteurella pneumonia	Respiratory disease affecting pigs 8-24 weeks	Aerosol form	**Acute:** fever, coughing, depression, mouth breathing, labored abdominal movements **Chronic:** intermittent cough, ill thrift	Good management practices; catching and treating it early to avoid spreading	Injected antibiotics for infected pig, others treated with feed or water additives for 5-7 days
Haemophilus pneumonia	Respiratory disease	Aerosol form	Severe respiratory distress, severe abdominal respiration, bloody discharge from nose and mouth **Fatal:** lying around with no desire to move **Chronic:** ill thrift, persistent cough, fever, respiratory distress	Well-ventilated, clean, uncrowded conditions	Antibiotics in feed and water; injections; isolating infected animals to prevent spreading; treating ASAP; immunity usually developed by treated pigs and passed on by immune sows through milk
Salmonella choleraesuis	Lung damaging	Enters body orally, multiplies in intestinal tract and spreads all over	Sudden death in previously healthy pigs; listlessness, difficulty breathing, death; purplish discoloration of ears, belly, feet or lower legs	Sanitation efforts, minimizing stress, preventive antibiotic therapy/vaccines	Water medication, individual injections; feed medications for long-term control
PRRS	Caused by a virus; produces a reproductive herd problem and a respiratory syndrome in pigs younger than 10 weeks	Pig-to-pig contact; aerosol form; shed from respiratory system, feces and semen	Difficulty breathing, deep cough, rough hair coat, poor growth, increase in secondary bacterial respiratory tract infections	Maintaining negative herd with tight biosecurity; getting replacements from known negative herds; using vaccines and all-in, all-out pig flows	No treatment for disease itself, so treat secondary problems

Cattle	What is it?	Mode of infection	Symptoms	Prevention	Treatment
Infectious Bovine Rhinotracheitis	Causes other respiratory and reproductive problems	Aerosol form and nose-to-nose contact, venereally or from contaminated examination instruments	Open-mouth breathing, fever, large amounts of nasal discharge, fiery red nose, depression, lack of appetite, labored breathing, coughing	Vaccines and natural immunity, less-confined environments	Antibiotics for secondary infections, but animals need to rid bodies of virus naturally
Pasteurella infections	Bacterial infection affecting feedlot, grouped or well-confined animals	Aerosol form, contact, feeding equipment	Fever, persistent cough, discharge from nose, rapid breathing, perhaps diarrhea, depression, lowering of heat, eye discharge	Reducing stress by avoiding quick ration changes, overcrowding, outside infections, stressful movements	Isolation in dry, warm, well-ventilated area; using antibiotics and proper environmental conditions to speed recovery
Bovine Respiratory Syncytial Virus	Usually affects weaning-age stock in feedlots during the summer	Aerosol form or contact	Coughing, depression, lots of nasal discharge, open-mouth breathing, frothing; also fever, severe respiratory distress and extension of the neck	Watching young stock closely, making gradual changes in diet or water, vaccinating	Providing antihistamines and vitamins; revaccinating for IBR
Bovine Virus Diarrhea	Frequently affects young (6-18 mo.) during winter	Aerosol form, by contact or infected urine and semen	Fever, depression, weakness, oral and nasal lesions, dehydration, diarrhea, lameness, nasal discharge, increased salivation, abortion **Acute:** death 3-4 days after infection	Vaccinating, avoiding stress	None--survivors to be destroyed

Horses	What is it?	Mode of infection	Symptoms	Prevention	Treatment
Strangles	Very contagious bacterial disease of upper respiratory tract	Inhaling/ingesting droplets from infected animal or from contact with humans who have been in contact with the disease	Very high fever, coughing, snorting, thick mucous discharge; throat, pharynx, larynx inflamed; difficulty swallowing	Isolating infected animals; providing heat, ventilation, room to move; avoiding overwork or severe weather conditions; disinfecting clothing afterward	Antibiotics, isolation of infected animals
Rhinopneumonitis	Viral disease in horses and donkeys	Aerosol form only	Usually mistaken for a cold--fever, congestion, nasal discharge, occasional coughing, loss of appetite	Providing well-ventilated, roomy quarters; vaccinations available but not guaranteed effective	Isolating infected animals; using antibiotics for secondary infections (special ones for nursing and gestating mares)
Equine influenza	Highly infectious, acute respiratory disease	Aerosol form, usually when moving/grouping horses	Fever, nasal discharge, depression, weakness, dehydration, loss of appetite	Vaccine, limiting outside contact with other horses	Treating quickly by isolating infected horses and keeping them in dry, warm, well-ventilated area; using antibiotics for secondary infections

BEST COPY AVAILABLE

UNIT IV - ANIMAL HEALTH
Name______________

Lesson 3: Respiratory Diseases Affecting Livestock
Date______________

EVALUATION

Fill in the blank with the best answer.

1. Administered medications used to prevent secondary infections from appearing in livestock are called __________________.

2. Medications used to prevent specific diseases from appearing in livestock are ______________.

3. When the nose of a hog turns to the left or right, this deformation is a symptom of ________________.

4. Food and water being regurgitated back through nostrils in horses is a symptom of _____________.

5. A producer should always _____________ infected animals from the rest of the herd to prevent spreading of disease.

Complete the following multiple answer questions.

6. Check all the modes of infection that apply to livestock respiratory diseases.

____ a. Feeding equipment
____ b. Human contact
____ c. Other animal contact
____ d. Aerosol form
____ e. Contaminated veterinarian utensils
____ f. Contaminated food
____ g. Contaminated water
____ h. Venereally

7. Check the appropriate symptoms of respiratory diseases in livestock.

____ a. Coughing
____ b. Increased appetite
____ c. Dehydration
____ d. Depression
____ e. Muscle contractions
____ f. Nasal discharge
____ g. Eye watering
____ h. Blindness
____ i. Open-mouth breathing
____ j. Fever

8. Check the appropriate preventive measures for livestock respiratory diseases.

____ a. Avoid stress.
____ b. Vaccinate.
____ c. Isolate infected animals.
____ d. Avoid ration changes.
____ e. Avoid overcrowding.
____ f. Avoid well-ventilated areas.
____ g. Avoid dry areas.
____ h. Avoid any sanitation practices.
____ i. Water down work area when working animals.
____ j. Develop a herd health program.

AS 3.1

Lesson 3: Respiratory Diseases Affecting Livestock

Name______________

RESPIRATORY DISEASES

While working through the lesson, fill out this chart to help you see the differences and similarities in the diseases.

Swine	What is it?	Mode of infection	Symptoms	Prevention	Treatment
Atrophic rhinitis					
Mycoplasma pneumonia					
Pasteurella pneumonia					

Swine	What is it?	Mode of infection	Symptoms	Prevention	Treatment
Haemophilus pneumonia					
Salmonella choleraesuis					
PRRS					

Horses	What is it?	Mode of infection	Symptoms	Prevention	Treatment
Strangles					
Rhinopneumonitis					
Equine influenza					

Cattle	What is it?	Mode of infection	Symptoms	Prevention	Treatment
Infectious Bovine Rhinotracheitis					
Pasteurella infections					
Bovine Respiratory Syncytial Virus					
Bovine Virus Diarrhea					

UNIT IV - ANIMAL HEALTH

Lesson 4: Diseases of the Gastrointestinal Tract

Objective: The student will be able to describe the diseases of the GI tract in livestock.

Study Questions

1. **What are the major GI diseases of swine, their symptoms, and treatments?**
2. **What are the major GI diseases of cattle, their symptoms, and treatments?**
3. **What are the major GI diseases of horses, their symptoms, and treatments?**

References

1. Student Reference

UNIT IV - ANIMAL HEALTH

Lesson 4: Diseases of the Gastrointestinal Tract

TEACHING PROCEDURES

A. Review

Review Lesson 2 in Unit I (Livestock Digestive Systems).

B. Motivation

Bring in the digestive tracts of different species of livestock. Consider bringing in disease-infested GI tracts. Bring in products used to treat GI diseases.

C. Assignment

D. Supervised study

E. Discussion

1. Ask the students what diseases they can think of that affect the digestive system of swine.

   What are the major GI diseases in swine, their symptoms, and treatments?

   a) Baby pig diarrhea
      1) Especially a problem in sows with poor milk flow and in unsanitary, continuous flow farrowing areas
      2) Causes: *Escherichia coli* (*E coli*), transmissible gastroenteritis (TGE), rotavirus, coccidiosis, *Clostridium perfringens* type C, and various combinations
      3) Symptoms
         (a) *E coli* bacteria adhere to the lining of the small intestine and produce toxins, which cause the intestine to secrete excess fluid. The affected pig has diarrhea and becomes ill from dehydration.
         (b) The viruses TGE and rotavirus infect and destroy the lining of the small intestine. The affected pig is contagious and has diarrhea and vomiting, which produces dehydration and starvation.
         (c) *Clostridium perfringens* type C is a toxin-producing bacterium that kills the lining of the small intestine. The pig can have bloody diarrhea and can die of dehydration and starvation.
         (d) Coccidia is a protozoan that infects the lining of the small intestine and causes death with improper absorption and digestion. As with the other pathogens, this produces diarrhea and results in dehydration and starvation. Pigs can only be treated with oral or injectable fluids.
      4) Treatment (except coccidiosis): antibiotics and oral or injectable fluids
      5) Prevention (except coccidiosis): sow vaccination before parturition for colostrum antibody production, cleaning, and disinfection to reduce the number of pathogens in the environment
   b) Adult diarrhea and gastrointestinal disease
      1) General
         (a) Usually occur after a pig has been weaned but can also occur in adult breeding animals
         (b) Controlled with good sanitation and all-in/all-out pig flow management

2) Swine dysentery
   (a) Causes: bacteria; can be carried by symptom-free animals
   (b) Symptoms: bloody diarrhea and inflammation of the large intestine
   (c) Treatment: appropriate antibiotics to the feed or water
3) Salmonellosis
   (a) Causes: bacteria, most commonly *Salmonella choleraesuis*
   (b) Symptoms: diarrhea, inflammation of both small and large intestines, infection of the bloodstream, high fevers, purplish skin around ears, snout, and flank
   (c) Treatment: antibiotics added to the feed or water
4) Proliferative enteritis
   (a) Causes: bacteria
   (b) Symptoms: inflammation and thickening of the intestinal lining, resulting frequently in dark, bloody diarrhea
   (c) Treatment: antibiotics
5) Whipworms
   (a) Cause: worm parasites
   (b) Symptoms: inflammation of the large intestine and bloody diarrhea
   (c) Treatment: deworming medicines
6) Gastric ulcers
   (a) Causes: finely ground feed and other factors
   (b) Symptoms: poor appetite and bleeding into the stomach, resulting in dark, tarry manure
   (c) Treatment: none practical

2. Ask the students if they think GI diseases in cattle will differ from those in swine. Have them review parts of the bovine digestive system. Discuss how this can cause diseases to differ. Also, emphasize that colostrum must be received by newborns within the first few hours of birth to ensure antibody protection.

What are the major GI diseases in cattle, their symptoms, and treatments?

NOTE: Proper management is extremely important, both in treating sick animals and eliminating factors that enhance bacteria and virus growth. Infected animals should be isolated and handled last. Keep newborns from having nose-to-nose contact. Keep birthing pastures or pens clean, treat navels to eliminate infection, and prevent overcrowding.

a) Four major categories: anatomical problems, mechanical problems, toxins, and infections (viral and bacterial)
b) Displaced abomasum

NOTE: Early diagnosis is particularly important as a case of simple displaced abomasum can progress to left displaced abomasum (LDA), right displaced abomasum (RDA), or abomasal volvulus, which is life threatening. Diseases such as ketosis, mastitis, and metritis can occur at the same time.

1) Cause: unknown--occurs when the abomasum (true stomach) gets out of position and becomes twisted
2) Symptoms: adults--decreased appetite, no cud chewing, decreased milk production, abdominal pain, a sprung rib cage, a temperature; calves--chronic bloating
3) Prevention: good feed management
   (a) Do not change feed rations too rapidly just before, or immediately after, parturition.

    (b) Make sure the dietary fiber needs are met in both quantity and fiber size.
    (c) With simple displaced abomasum, laxatives or antacids can be effective, as can a "rolling" technique.
    (d) Surgery is usually required for valuable cattle with LDA, RDA, or abomasal volvulus.
c) Vagus indigestion
  1) Occurs when the main nerve (vagus nerve) controlling gastrointestinal movement (motility) is damaged or pinched
  2) Symptoms: lack of appetite, lack of intestinal sounds, death
  3) Treatment: recovery time or veterinary treatment
d) Extreme wear or loss of teeth
  1) Can occur very rapidly, depending on the geographic region and feeding practices
  2) Causes: age and some diseases, primarily nutrient deficiencies or excesses of calcium, phosphorus, and Vitamins D and A
e) Intestinal tortions, intussusception, and hernias
  1) Symptoms: loss of appetite, blockage of the intestine, severe pain, and eventual death
  2) Treatment: surgical intervention of a veterinarian
f) Prolapsed rectum
  1) Causes: severe coughing/respiratory disease, diarrhea, or straining from constipation
  2) Treatment: early recognition, surgical repair, and correction of the true cause
g) Hardware disease
  1) Most frequently seen with dairy cows
  2) Cause: swallowed debris, such as wire and nails
  3) Symptoms: appetite loss, standing quietly with an arched back, impaired milk and other body functions, frequent urination, difficult breathing, slight temperature, grunting sound
  4) Treatment: reducing feed intake, allowing the animal to remain still, broad-spectrum antibiotics, surgery
  5) Prevention: magnet in reticulum
  6) X-ray or exploratory surgery needed for definite diagnosis
  7) Chronic cases difficult to diagnose because of confusing signs as the hardware moves through the body
h) Bloat
  1) Occurs when the esophagus becomes blocked where it opens into the rumen; prevents the animal from burping normal rumen gases
  2) Causes: something lodged in the esophagus, a cancerous growth, overeating of grain or legumes, or injury
  3) Symptoms: off their feed, a ballooned left abdominal wall, or in severe cases, both sides of the abdomen and death
  4) Treatment: passing a tube down the esophagus to release the gas, placing supporting medication into the rumen, surgical release of the gas
i) Ulcers
  1) Can occur at any point along the gastrointestinal tract, although true stomach ulcers occur only in the abomasum
  2) Causes: ingested toxins, viruses, or improper diets
  3) Symptoms: poor appetite, dark feces if bleeding is occurring
  4) Treatment: Supportive care and medication until the ulcers heal themselves
j) Toxins
  1) Causes: contact with harmful manufactured sources or naturally occurring plants; orally or through the skin
  2) Symptoms: vary from mild lack of appetite to severe constipation or diarrhea; can affect other organ systems

        3) Treatment: (by veterinarian) antidotes, laxatives, and absorbents
        4) Prevention: prevent exposure to toxins
    k) Scours/diarrhea
        1) Particularly deadly for calves younger than 10 days old
        2) A veterinarian and diagnostic laboratory often needed for diagnosis
        3) Causes
            (a) Bacteria: *E coli, Salmonella,* and *Clostridium perfringens* types A, B, C, E
            (b) Viruses: rotavirus, coronavirus, IBR, and BVD
            (c) Contributing environmental factors, such as overcrowding, lack of colostrum, vitamin deficiency, and parasites
        4) Symptoms: watery feces, weight loss, dry skin, weakness, depression, death
        5) Treatment
            (a) For dehydration, oral fluids, electrolyte therapy, antibiotics
            (b) For sick calves, milk replacer, electrolytes, antibiotics
        6) Prevention: cow vaccination against colibacillosis, *Salmonella, Clostridium,* rotavirus, coronavirus, IBR, and BVD so that antibodies will be passed on in colostrum; proper management; internal parasite control

3. Ask the students if GI diseases in horses are similar to or different from those in other livestock. Does the difference in digestive tracts have an effect on the types of GI diseases horses can contract?

What are the major GI diseases in horses, their symptoms, and treatments?

a) Equine colic
    1) Most frequently seen gastrointestinal problem in horses
    2) Not a single disease, but a symptom of pain in the abdomen
    3) Causes: anatomical combined with poor management
        (a) Anatomical: relatively small stomach; inability to vomit; and large, free-moving intestines
        (b) Management: sudden changes in feeding or watering, too little forage, over-feeding/overwatering recently worked horses, working horses immediately after a full feeding, moldy grain or hay, and parasite buildup
    4) Symptoms
        (a) Mild pain: depression, pawing, lack of appetite, decreased bowel movement, yawning, looking toward flanks, excessive lying down, repeatedly getting up and down, frequent attempts to urinate, tail twitching, and kicking at the belly
        (b) Moderate pain: rolling or thrashing dangerously, patchy sweating, rapid breathing
        (c) Severe: rolling and thrashing uncontrollably, profuse sweating, and ignoring attempts at restraint
    5) Treatment: keeping horse on its feet while waiting for the veterinarian, walking the horse slowly
        (a) Medical colic: pain relievers, laxatives, withholding feed, general nursing care, follow-up exam
        (b) Surgical colic: surgery, euthanasia
b) Diarrhea
    1) Less common in horses
    2) Causes: strongyle infestation, too much milk, bacterial and viral diseases, sudden changes in feed, or at the first normal heat after foaling
    3) Treatment: antibiotics and medicines containing kaolin or pectin

F. Other activities

1. Have the local veterinarian bring in GI tracts from various species and talk about disease causes and treatments.

2. Bring in various products used in the treatment of GI diseases. Discuss how they work and how to use them properly.

G. Conclusion

The symptoms and causes of many digestive disturbances are very similar. Correct treatment depends on identifying the specific disease properly. Prevention, through proper sanitation and management, seems to be the key to controlling GI diseases.

H. Competency

Describe the diseases of the gastrointestinal tract in livestock.

Related Missouri Core Competencies and Key Skills

10B-5: Associate common human diseases with organs affected.
10D-1: Describe general ways in which human activities affect environmental quality.
10D-3: Identify problems caused by overpopulation and develop possible solutions.
10F-4: Identify the relationship among volume, pressure, and temperature of a confined gas.

I. Answers to Evaluation

1. d
2. b
3. a
4. c
5. a
6. d
7. a, c, d, f, g, h, i (question worth 10 points)
8. b, e, g (question worth 8 points)

UNIT IV - ANIMAL HEALTH Name______________

Lesson 4: Diseases of the Gastrointestinal Tract Date______________

EVALUATION

Circle the letter corresponding to the correct answer.

1. Which of the following destroys the lining of the small intestine and causes death in pigs?

   a. Scours
   b. Rumenstasis
   c. Salmonellosis
   d. TGE

2. Newborn animals should receive a full feeding of ______________ during the first few hours of life to ensure defense against many diseases.

   a. Electrolytes
   b. Colostrum
   c. Milk replacement
   d. Water

3. Placing a magnet into the animal's reticulum can prevent which condition?

   a. Hardware disease
   b. Rumenstasis
   c. Colic
   d. Bloat

4. An animal doing complete, continuous rolls on its back shows signs of which disease?

   a. Diarrhea
   b. Constipation
   c. Equine colic
   d. Salmonellosis

5. For which disease is the cause unknown?

   a. Displaced abomasum
   b. Vagus indigestion
   c. Prolapsed rectum
   d. Bloat

6. Vaccination and antibiotics are effective against all but which cause of baby pig diarrhea?

   a. *E coli*
   b. TGE
   c. Rotavirus
   d. Coccidiosis

Complete the following multiple answer questions.

7. Which of the following contribute to colic in horses?

___a. Relatively small stomach
___b. *E coli* bacteria
___c. Inability to vomit
___d. Large, free-moving intestines
___e. Lack of colostrum
___f. Sudden changes in feeding or watering
___g. Too little forage
___h. Moldy grain or hay
___i. Parasite buildup
___j. Overcrowding

8. A cow is off her feed and her left side is swollen around the abdomen. Which are appropriate treatments?

___a. Isolation from the herd
___b. Passing a tube down the esophagus
___c. Plenty of fluids
___d. Broad-spectrum antibiotics
___e. Medication in the rumen
___f. Antidotes and absorbents
___g. In severe cases, surgery
___h. Euthanasia

UNIT IV - ANIMAL HEALTH

Lesson 5: Reproductive Diseases in Livestock

Objective: The student will be able to understand and describe the diseases of the reproductive system in livestock.

Study Questions

1. **What are the major reproductive diseases of swine, their symptoms, and treatments?**
2. **What are the major reproductive diseases of cattle, their symptoms, and treatments?**
3. **What are the major reproductive diseases of horses, their symptoms, and treatments?**

References

1. Student Reference

Lesson 5: Reproductive Diseases in Livestock

TEACHING PROCEDURES

A. Review

Review previous lesson on the diseases that affect the gastrointestinal tract in livestock.

B. Motivation

Why is it important to know reproductive diseases in livestock? People in the livestock industry are well aware of the economic importance of preventing reproductive diseases in livestock. Reproductive diseases can cause major losses in a single livestock operation, as well as the entire livestock industry. To keep losses from occurring, a producer must be aware of symptoms, preventive measures, and treatments. Quick isolation of infected animals helps prevent spreading of the disease. Good management and sanitation practices are effective preventive measures.

C. Assignment

D. Supervised study

E. Discussion

1. Abortions in animals represent genetic and economic losses and frequently cause a serious disposal problem, especially if the abortion resulted from an infectious disease. Abortions can be caused by thousands of factors, so diagnosis of the cause of an abortion can be very difficult. The diagnostic success rate for abortion is only about 30 percent. Researchers say abortion losses of 2-3 percent can be tolerated without undue concern in well-managed livestock operations. See if students can come up with some major reproductive diseases in swine.

   What are the major reproductive diseases of swine, their symptoms, and treatments?

   a) Pseudo-rabies
      1) Description - Pseudo-rabies is an acute, frequently fatal disease occurring in all ages of swine. The most susceptible population is less than two months of age. This disease is usually spread by a virus present in the sow's milk or in the boar's semen.
      2) Symptoms - Young pigs usually die right away or are aborted by the sow. Older pigs or weaning-age pigs show signs of fever, incoordination, walking sideways, tremors, mouth frothing, eye discharge, and sometimes convulsions. Vomiting, diarrhea, and death will soon follow. Adult swine show signs of fever, vomiting, muscle spasms in limbs, convulsions, or intense itching. Adults might also have respiratory problems. The most prominent sign in females is aborting their young.
      3) Prevention - The only preventive measure is to test incoming stock for pseudo-rabies. Any stock that tests positively for pseudo-rabies must be destroyed.
      4) Treatment - The only treatment for positively tested stock is to destroy those animals to prevent further spreading of the disease.

   b) Leptospirosis
      1) Description - Leptospirosis affects all populations of swine. It is transmitted through wallowing in muddy areas infected by contaminated urine. Other methods of transmission are infected dead pigs and outside animals entering confined

quarters. The organism usually confines itself to the area of the bladder. The organism can survive for several months in stagnant waters. Infection usually occurs through the nasal and oral passages by nosing at urine or eating contaminated fetus, food, soil, or water.

2) Symptoms - Reproductive disorders usually show as abortions, infertility, stillbirths, fever, reduced milk, and neonatal mortality. Acute cases show signs of dullness, diarrhea, hindquarter weakness, incoordination, staggering gait, and stiffness of neck.

3) Prevention - Vaccinations are available to prevent leptospirosis. Vaccinations for sows should be done prior to mating and just before farrowing. This method is very beneficial for confined farrowing operations. Outside animals entering the herd should be isolated, vaccinated upon arrival, and again 4-6 weeks after they enter the herd. Pigs should be vaccinated at weaning and again 4-6 weeks later. Good management practices, such as cleaning pens and eliminating stagnant waters and rodents, are good preventive measures.

4) Treatments - Feed additives can eliminate carrier animals by treating the entire herd for 8-11 days. There are several drugs available that are effective for treating infected animals.

c) Brucellosis

1) Description - Brucellosis attacks all breeds, classes, and ages of swine. There is no lasting immunity for brucellosis; infected animals that recover can be reinfected with the disease later in their lifetime, usually 6-12 months after recovery. There are several modes of infection. The germ can be present in the urine of both sows and boars, in semen, vagina discharges, food and water troughs, sow's milk, and even in the soil. The germ enters the body through the mouth from any of the above sources. It can be transferred from pen to pen by human clothing, boots, farrowing crates, and feed buckets. Transmission of brucellosis can also occur when hogs eat or come in contact with infected, aborted fetuses. The disease can be readily transferred from the boar to sow during mating.

2) Symptoms - In boars, one or both testicles appear swollen. If not caught early enough, the boar generally becomes impotent. In the female, symptoms appear in their offspring, not in the sow herself. Since each fetus has its own placenta, some pigs are born normally developed, but others might be born dead and underdeveloped. Abortions can occur but are rare in swine. Once an abortion occurs, the sow generally eats her young.

3) Prevention - Isolating and testing sows that have abortions or stillborns is a good preventive measure. Good sanitation practices, such as cleaning and disinfecting farrowing crates, help prevent brucellosis. Always isolate and test outside animals coming into the herd to ensure containment of the disease.

4) Treatment - No drugs are available at this time to effectively treat brucellosis, so destroying all animals that test positive for it is the only treatment.

d) Parvovirus

1) Description - Parvovirus is probably the most infectious virus that affects swine because of its resistance to heat, cold, acidity, alkalinity, and disinfectants. Parvovirus affects all breeds, classes, and ages of swine. Infection can occur venereally, by inhalation, and by ingestion. Pigs affected by parvovirus in their adolescent years will probably develop a natural immunity for the remaining years of production.

2) Symptoms - Parvovirus usually appears in the form of reproductive problems in swine. Sows will have problems conceiving, stillbirths, reduced litter sizes, and mummification of fetuses. Boars will have infertility problems.

3) Prevention - It is important to isolate animals that are suspected of infection and outside animals entering the herd for testing. Infected animals generally shed the

virus in their fecal matter, so good sanitation practices are also important. There are vaccinations available for parvovirus.

4) Treatment - Isolating and vaccinating infected animals is usually the best form of treatment for parvovirus.

2. See if students can come up with some major reproductive diseases in cattle.

What are the major reproductive diseases of cattle, their symptoms, and treatments?

a) Brucellosis
   1) Description - Brucellosis is a very contagious bacterial disease in cattle. Brucellosis is an important livestock disease because it can be transmitted to humans very easily. The bacteria enters the body through the mouth or venereally. Transmission occurs by licking genital organs, infected fetus, infected placenta, or by licking vaginal discharges. Transmission can also occur during natural servicing of females, but this is very rare. Females are more susceptible than males, and older animals seem to be more susceptible than younger animals. Time of the year, climate, and weather have little influence on the brucellosis bacteria.
   2) Symptoms - Abortions in cattle are a significant sign of brucellosis, but not all infected females abort their fetuses. Other symptoms are weak calves at birth, retained placenta, and vaginal discharge. These symptoms lead to a period of infertility for both the female and male. An infected male will usually have a reduced sex drive and enlargement of one or both testicles.
   3) Prevention - Calf vaccination and good sanitary practices are vital in preventing brucellosis from entering the herd. Annual brucellosis testing of the herd is a good preventive measure.
   4) Treatment - Isolating infected animals is vital in preventing the disease from spreading. All infected animals must be destroyed.

b) Mastitis
   1) Description - Mastitis is more common in dairy than in beef cattle because dairy cattle come in contact with more outside sources. All breeds of dairy and beef cattle are susceptible to this disease. It is considered a reproductive disease because it appears only after parturition. Infection usually occurs by bacteria transfer from the milker's hand, milking equipment, flies, or by lying on infected ground. The bacteria enters the body through the hole in the end of the teat. Cows that have been affected by the disease will not become immune to the disease; it can reoccur again and again.
   2) Symptoms - A true sign of mastitis is changing the true nature of milk. Infected milk has thick, white, pus-like clots in it. Clots resemble paper spit-wads. The milk usually becomes paler and thinner. The infected milk has a very unpleasant odor since it is infected with pus. The udder becomes hot, tense, and painful for the animal. The udder might also develop lumps that can be felt by the producer.
   3) Prevention - There are several teat dips available to prevent mastitis. Dipping the teats after milking is a good management practice. Good cleaning practices for the milking parlor and milking equipment are also good preventive measures.
   4) Treatment - There are several drugs available for treating mastitis. These drugs should be administered to the infected animal until the animal is fully recovered. Infected milk must be disposed of properly. There is usually a waiting period until the milk returns to the herd's milk supply.

c) Metritis
   1) Description - Metritis means inflammation of the uterus or breeding bag. Metritis is not a specific disease but a condition or symptom of a variety of bacterial diseases. Infection can occur venereally, through contaminated obstetrical equipment (calf pullers and chains), by human contact after working with infected

animals, and improper clean-up. Afterbirth removal by manual, rough, or early means are predisposing causes for metritis. The retained placenta acts as a wick for infection to the uterus.

    2) Symptoms - Females affected by metritis have inflammation of the mucus membrane lining of the uterus. This inflammation creates outward signs of vaginal discharge in the form of excess mucus, pus flakes, or excess pus. Breeding problems usually occur, such as conception problems, missed heat cycles, and a fertilized egg that cannot attach itself to the uterus wall. These problems occur because of inflammation in the uterus. Bulls are usually unaffected by the disease but can be carriers.
    3) Prevention - Good sanitation and feeding practices are preventive measures. If an outbreak occurs, isolate infected animals; make sure equipment and clothing are cleaned after working with infected animals. An outbreak of metritis is more likely to occur in confined areas like calving barns. (There is a higher concentration of infectious diseases in confined areas than in the outside environment.)
    4) Treatment - There are several drugs available for treatment of infected females. Consulting the veterinarian will produce the most effective results.
d) Leptospirosis
    1) Description - Leptospirosis affects all classes, breeds, and ages of cattle. Like swine, the disease is transmitted through infected urine. Transmission generally occurs by inhaling infected urine droplets that are present in the air. Animals that recover from leptospirosis generally develop a high resistance to reinfection. Low-lying ground with swampy conditions and stagnant puddles of water are predisposing causes for leptospirosis.
    2) Symptoms - Acute symptoms of leptospirosis are fever, depression, failure to eat, and reduced milk production. Some chronic symptoms are abortions, breeding difficulty, death, and retained placenta.
    3) Prevention - The best form of prevention is to isolate infected animals from the rest of the herd. Be aware of any stagnant bodies of water if there is an outbreak of leptospirosis in the herd. There are vaccinations available for prevention of this disease.
    4) Treatment - Several drugs are available for treatment of leptospirosis. It is best to consult a veterinarian for effective treatment.

3. See if students can come up with some major reproductive diseases in horses.

What are the major reproductive diseases of horses, their symptoms, and treatments?

a) Metritis
    1) Description - Metritis affects all classes and breeds of breeding stock in horses. The most susceptible population is breeding mares. Infection can occur venereally, through contaminated obstetrical equipment (such as foal pullers and chains), by human contact after working with infected animals, and improper clean-up. The retained placenta acts as wick for infection to have a direct route to the uterus.
    2) Symptoms - Symptoms of metritis are more difficult to detect than other diseases because animals usually appear to have breeding problems. Mares show no signs of vaginal discharge. The only signs are failure to conceive or maintain pregnancy. Other signs of metritis are repeated service to a known fertile stallion. Sometimes a mare appears to have conceived by missing a heat cycle, but after 2-3 months later a fetus is not found because the fertilized egg could not attach itself to the uterus wall.

3) Prevention - If an outbreak occurs, isolate infected animals and make sure equipment and clothing are cleaned after working with infected animals.

4) Treatment - The following are effective treatments for metritis: local antibiotic therapy, systemic antibiotics, topical antiseptic therapy, uterine flushes, plasma infusion, and a combination of plasma infusions and antibiotics.

b) Fescue toxicity

1) Description - Fescue toxicity affects female breeding stock in horses. Infection occurs when gestating mares eat fungi-infected fescue grass. By eating infected fescue, production of the hormone prolactin is reduced. Prolactin reduction decreases or eliminates milk production in the mare. This process generally takes place in the last 60 days of gestation.

2) Symptoms - Fescue toxicity is generally too hard to detect until it is too late, but there is one indication that can lead to the detection of it. If the mare was on a fescue diet and gestating, the lack of udder development is a good indication of fescue toxicity. After foaling, signs of fescue toxicity are stillborns and thick, discolored placenta.

3) Prevention - A good preventive measure is to pull gestating mares off their fescue diet 60 days prior to foaling to reduce fescue toxicity chances.

4) Treatment - Since fescue toxicity is not an infection, treatment for the disease is not necessary to aid in recovery. Good management practices are the most effective way to prevent fescue toxicity.

F. Other activities

A local veterinarian could talk to students about setting up health programs necessary for a healthy herd.

G. Conclusion

It is important for livestock producers and others in the livestock industry to understand the impact of reproductive diseases. The producer is the first step in detection, prevention, and treatment of reproductive diseases, so it is vital that a producer understand the impact of health on the herd.

H. Competency

Describe the diseases of the reproductive system in livestock

I. Answers to Evaluation

1. b
2. a
3. d
4. b
5. c
6. d
7. b
8. c
9. d
10. b
11. a, b, e, f, g (question worth 10 points)
12. b, c, d, g, h (question worth 10 points)
13. a, d, e (question worth 10 points)

UNIT IV - ANIMAL HEALTH Name______________

Lesson 5: Major Reproductive Diseases in Livestock Date______________

EVALUATION

Circle the letter that corresponds to the best answer.

_____ 1. Which pork reproductive disease is transmitted by inhaling infected urine droplets?

a. Pseudorabies c. Brucellosis
b. Leptospirosis d. Parvo virus

_____ 2. Which reproductive disease in cattle is the most infectious to humans?

a. Brucellosis c. Metritis
b. Mastitis d. Leptospirosis

_____ 3. A good preventive measure for fescue toxicity is to remove horses from a fescue diet _____ days before foaling.

a. 30 c. 50
b. 45 d. 60

_____ 4. White, pus-like clots found in milk are symptoms of what reproductive disease in cattle?

a. Brucellosis c. Metritis
b. Mastitis d. Leptospirosis

_____ 5. Which reproductive disease deals strictly with a cow's uterus or breeding bag?

a. Brucellosis c. Metritis
b. Mastitis d. Leptospirosis

_____ 6. Which reproductive disease is considered the most infectious viral disease in swine?

a. Pseudo-rabies c. Brucellosis
b. Leptospirosis d. Parvovirus

_____ 7. In swine, the destruction of infected animals is the only effective treatment for which two diseases?

a. Pseudo-rabies and leptospirosis c. Parvovirus and brucellosis
b. Pseudo-rabies and brucellosis d. Parvovirus and leptospirosis

_____ 8. Placenta removal before it is ready to be taken away, manual removal, and rough removal of placenta are predisposing causes for which reproductive disease in cattle?

a. Brucellosis c. Metritis
b. Mastitis d. Leptospirosis

_____ 9. What reproductive disease is likely when a mare appears to have conceived but has not formed a fetus three months later?

a. Leptospirosis
b. Brucellosis
c. Fescue toxicity
d. Metritis

_____ 10. Stagnant, infected bodies of water is a predisposing cause for which reproductive disease in swine?

a. Pseudo-rabies
b. Leptospirosis
c. Brucellosis
d. Parvovirus

Place a check by the appropriate symptoms for the following diseases.

11. What are the acute symptoms of leptospirosis in swine?

____ a. Dullness
____ b. Diarrhea
____ c. Retained placenta
____ d. Lumps in udder
____ e. Incoordination
____ f. Staggering gait
____ g. Stiffness of neck
____ h. Lack of appetite
____ i. Nervous disorders
____ j. Tail biting

12. What are the symptoms of mastitis in cattle?

____ a. Lack of appetite
____ b. White clots in milk
____ c. Unpleasant odor from milk
____ d. Lumps in udder
____ e. Diarrhea
____ f. Fever
____ g. Udder feels hot
____ h. Milk thinner in nature
____ i. Staggering gait
____ j. Respiratory problems

13. What are symptoms of fescue toxicity in horses?

____ a. Lack of development of udder
____ b. Diarrhea
____ c. Lack of appetite
____ d. Discolored placenta
____ e. Stillborns
____ f. Fever
____ g. Staggering gait
____ h. Dullness
____ i. Lumps in udder
____ j. Respiratory problems

UNIT IV - ANIMAL HEALTH

Lesson 6: External and Internal Parasites

Objective: The student will be able to describe the external and internal parasites of livestock and poultry.

Study Questions

1. **What are the major external parasites of livestock, their symptoms, and treatments?**
2. **What are the major internal parasites of livestock, their symptoms, and treatments?**
3. **What are the external parasites of poultry, their symptoms, and treatments?**
4. **What are the major internal parasites of poultry, their symptoms, and treatments?**

References

1. Student Reference

283

Lesson 6: External and Internal Parasites

TEACHING PROCEDURES

A. Review

Review Lesson 4.

B. Motivation

Bring in pictures of internal and external parasites. Bring in products used in the treatment of internal and external parasites. Discuss what they are and what they are used for.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss what some external parasites of livestock might be. Ask the students what products are used to control parasites in livestock. Are there any similarities in parasites of different species?

What are the major external parasites of livestock, their symptoms, and treatments?

a) Ticks
   1) Hosts - Ticks attack all classes of livestock but are of greatest concern to cattle and horse producers.
   2) Life cycle - After leaving the host, the adults lay eggs that hatch into larvae in 10-21 days to three weeks. The larvae become nymphs and attach to a host until they become mature adults, which range from a few days to several months, depending upon the species.
   3) Damage - The greatest damage to hosts by ticks is the sucking of blood, which can cause anemia, weight loss, and even death. They also leave a wound that encourages bacterial infection or other injury.
   4) Symptoms - Infestations are usually found by visual inspection.
   5) Control - Extreme temperatures and pasture rotation help control ticks. The most effective method of control is chemical treatment.

b) Louse
   1) Hosts - Lice are species specific, and only one species affects swine--the hog louse.
   2) Life cycle - The adult female glues her eggs to the hairs of the host. Hatching times range from 1-2 weeks, when the nymphs are produced. In 2-4 weeks, the nymphs become mature adults.
   3) Damage - Bloodsucking lice can cause the hosts to become anemic. Irritation and discomfort cause rubbing and scratching. This decreases feeding and grazing time, resulting in loss of gains, unthriftiness, and even death.
   4) Symptoms - The primary symptoms of lice infestations are rough hair coats, rubbing, and scratching.
   5) Control measures - Chemical control by pesticide sprays, dips, dust, and self-treatment devices are most effective.

c) Mite
    1) Hosts - Mites attack all classes of livestock.
    2) Life cycle - Mites spend their entire lives on the host. The adult female lays its eggs on the surface of the host's skin. The eggs hatch in approximately four days, and larvae emerge. The larvae molt, become nymphs, molt again, and become adults. The entire life cycle takes 12 days or less.
    3) Damage and symptoms - Hair falls out and the skin becomes rough and crusty.
    4) Control measures - Mites can be chemically controlled. Animals having this pest are placed under quarantine.

d) Screwworm
    1) Hosts - The screwworm affects all livestock. Usually, infestation is only through wounds; however, some infestations have been found without wounds.
    2) Life cycle - The screwworm is the larvae stage of the blowfly. It feeds on living flesh for 5-7 days, drops to the ground, and pupates.
    3) Damage - The larvae or maggots live on live flesh and can cause weight loss, permanent injury, or even death.
    4) Symptoms - The primary signs of screwworms in a wound are an unpleasant odor, enlargement of the wound, and seepage of blood serum from the wound.
    5) Control - Sprays are available for the treatment of screwworm infestation.

e) Heel fly or cattle grub
    1) Hosts - Cattle are the primary hosts for the cattle grub; however, they have been found with other species.
    2) Life cycle - The adult fly lays eggs on the hairs of the legs and lower parts of the host's body. The eggs hatch into larvae that penetrate the hair follicles and enter the animal's body. During a period of months, the larvae migrate through fleshy tissues of the animal's body until they reach the back.
    3) Damage - The primary damage is to the hides because of decreased values from the holes. During fly strike, when flies attack cattle in swarms, cattle are likely to hurt themselves as they try to get away from the flies. There is also damage to meat that must be trimmed away as waste.
    4) Symptoms - The presence of the host fly is evident during egg laying. There is visible swelling of the grubs once they arrive in the animal's back.
    5) Control - The best control method is to use systemic insecticides before heel flies reach the animal's back.

f) Horn fly
    1) Hosts - Cattle are the main hosts, but horn flies will attack other species.
    2) Life cycle - The adult female lays her eggs in manure, where they hatch in nearly 24 hours. The larvae mature in 5-10 days and then pupate. Young flies emerge from the pupae in 3-7 days and become adults in a few days.
    3) Damage - The adult fly bites and sucks blood from the head, neck, back, and belly of cattle. The biting transmits disease, annoys the animal, and indirectly causes weight loss.
    4) Symptoms - Horn flies are easily seen on infested animals. Unless they are controlled, horn flies will cover the backs and necks of cattle during the spring and summer.
    5) Control - Chemical control is the best method. Feed additives and ear tags containing insecticides are other available methods for controlling horn flies.

g) Other flies
    1) Hosts - Flies are parasites of all classes of livestock.
    2) Life cycle - The adult female lays eggs in manure, debris, and other dead and decaying organic matter. The eggs hatch into larvae in approximately 24 hours. The larvae mature and pupate in 5-10 days. Flies emerge from the pupae in 5-7 days and become adults in only a few days.

3) Damage - Besides biting, sucking blood, and transmitting diseases, flies annoy animals, indirectly causing lowered feed gains and weight loss.

4) Symptoms - Flies are easily seen, and heavy infestations are common around lots and barns.

5) Control - Most flies can be controlled with chemical sprays and dusts or feed additives. Because most species build up an immunity to nearly all chemicals, rotation in the use of chemicals is recommended.

h) Nose bots

1) Hosts - The nose bot is a parasite of horses and sheep and is closely related to the heel fly.

2) Life cycle - The adult fly emerges from the pupae, which lies dormant in feces and other debris until the first warm days of spring, late summer, or early fall. While grazing, the animals rub their noses against the ground; the fly deposits the eggs on the nose and chin of the animals.

3) Damage - Large infestations of the bot in the animal's stomach reduce digestion and usually leave an ulcerated area.

4) Symptoms - The presence of the adult fly is very obvious because of the irritation it causes the animals.

5) Control - Chemical control through deworming is the only method of control.

2. Discuss what some internal parasites of livestock might be. Ask the students about products used to control parasites in livestock. Are there any similarities in parasites of different species?

What are the major internal parasites of livestock, their symptoms, and treatments?

a) The internal parasites which affect livestock are divided into three major groups.

1) Roundworms
2) Flukes
3) Tapeworms

b) Roundworms - From an economic standpoint, roundworms are the most important parasites. There are many types that affect almost every species of livestock. Although there are species which attack every system in the body, the ones of greatest concern are found in the digestive system (mostly the stomach and intestines).

1) Stomach worms - There are several species of stomach worms, but the twisted stomach worms and the brown stomach worms are most important.

(a) Hosts - Stomach worms are found in all classes of livestock but commonly affect cattle, sheep, and horses.

(b) Life cycle - In the adult stage, stomach worms live as bloodsucking parasites attached to the stomach wall. The eggs pass from the host in the feces and hatch into larvae in 15-20 days, depending on temperature and humidity. The larvae crawl up a blade of grass, are eaten by the animal, and travel to the stomach lining until they mature.

(c) Damage - While penetrating the stomach lining before maturing, they cause severe damage by reducing nutrient digestion and producing poisons. Young, undernourished, or diseased animals are hardest hit.

(d) Symptoms - The most common symptom is anemia. In light infestations, the animal will have a dull hair coat, an unthrifty appearance, and sometimes scours. In severe infestations, there will be persistent scouring, weight loss, anemia, weakened condition, and possibly death.

(e) Control - Sanitation and pasture rotation are good control measures. Chemical dewormers are used in treating infested animals. The type of dewormer used is dependent upon the class of livestock. Drenches and injectable dewormers are most often used in cattle and sheep. Feed and water additives are generally used for swine. Liquid dewormers, administered by tubing, are the most effective treatment for horses. Feed additives are also very effective.

2) Strongyles - There are several species of strongyles (bloodworms) that normally inhabit the small intestine and are also found in the abomasum of ruminants.
   (a) Hosts - Strongyles attack all species and have a greater effect on young animals of each species. After cattle and horses reach an age of 4 or 5 years, they build up a partial immunity and are less affected.
   (b) Life cycle - Adult stage strongyles live as bloodsucking parasites attached to the lining of the intestines. Eggs pass from the host in the feces and hatch into larvae within 5-20 days, depending upon temperature and humidity. The larvae then attach to a blade of grass, are eaten by an animal, pass through the stomach, and attach to the wall of the intestine. The larval stage strongyles can live for months in the grass before being eaten. Larvae pass through the arteries and other internal organs, sometimes causing irreparable damage.
   (c) Damage - Strongyles (bloodworms) are the most detrimental of all internal parasites. Besides sucking blood, which results in anemia, their presence and the scar tissue they leave greatly reduce digestion in the intestines. They are the major cause of colic in horses. In chronic infestations, their presence results in unthriftiness, poor feed conversion, weakened condition, and even death in all livestock.
   (d) Symptoms - The most common symptom is anemia. In moderate and severe infestations, animals have weight loss, rough hair coats, scouring, loss of appetite, colic, and weakness.
   (e) Control - Sanitation and pasture rotation are effective in helping control strongyles. The use of chemical dewormers in a regular deworming program is the best method of control. In cattle and sheep, deworming, boluses, drenches, and injectable dewormers are the most effective. For swine, water and feed additives are most often used. For horses, tubing at regular intervals plus feed dewormers between tubings give the best results.

3) Ascarids - Largest of the roundworms
   (a) Hosts - Primarily, ascarids prey on cattle, sheep, hogs, and horses. Younger animals are most often affected.
   (b) Life cycle - Eggs are passed in the feces and contaminate pastures, lots, and stable areas, where they are ingested by susceptible hosts. The larvae burrow into the intestine wall and migrate through the liver, heart, and finally the lungs, where they are coughed up and swallowed. After reaching the intestines the second time, they develop into the adult stage, where they reach a length of 8-15".
   (c) Damage - Affected animals can develop pneumonia and lung damage due to the larval migration through the lungs. Unthriftiness, weight loss, and colic due to intestinal blockage are common in heavy infestations.
   (d) Symptoms - Weight loss, dull hair coat, general unthriftiness, and colic are noticed.
   (e) Control - Generally, ascarids are controlled by the same means as other stomach and intestinal roundworms--pasture rotation, sanitation, and deworming programs.

4) Pinworms - Small roundworms usually found in the colon or rectum of horses
   (a) Hosts - Predominantly, pinworms are a parasite of horses.
   (b) Life cycle - Adult females lay eggs around the anus of the horse. These eggs drop off and contaminate pastures, stables, and watering and feeding areas. After eggs are ingested by the host, they pass to the colon and rectum to mature.

(c) Damage - Damage by pinworms is minor. However, they do cause severe irritation around the tail area, which causes horses to rub their tails.

(d) Symptoms - Tail rubbing is the most noticeable symptom. Also, white scaly deposits are visible around the anus.

(e) Control - Chemical worming programs used to control other species of roundworms will control pinworms. Sanitation measures around barns and lots are effective in reducing infestations.

5) *Habronema* - This species affects the host in two stages.

(a) Host - The horse is the major host of the *Habronema* stomach worm, but the house fly is an intermediate host.

(b) Life cycle - The adult stage is found in the horse's stomach, where little damage occurs other than an occasional tumor. Larvae are passed in the feces, which are ingested by house fly maggots. They remain in the fly when it emerges from the pupal stage. The larvae of the *Habronema* are swallowed, deposited on the lips of the horse by the fly, and mature in the horse's stomach.

(c) Damage - Real damage of the *Habronema* does not involve its normal life cycle. If the larvae is deposited on an open wound, a summer sore develops. These summer sores are difficult to heal and are the result of the migration of *Habronema* larvae throughout the wound. They can permanently disable or disfigure horses. These sores also develop around the medial canthus (corner of the eye nearest the bridge of the nose), especially in stabled horses.

(d) Symptoms - A summer sore is easily detected by a seepy, hard-to-heal crusty sore. In the eye there is excessive tearing and running, which later forms an open sore. The larvae can be seen upon close inspection.

(e) Control - As with other roundworms, disruption of the life cycle is necessary. The best control is a regular deworming program. Sanitation is important, along with a fly control program in and around the stable area.

6) Lungworms - These roundworms affect the circulatory system and lungs.

(a) Hosts - Lungworms affect all species of livestock.

(b) Life cycle - Eggs are laid in the lungs, then coughed up and swallowed. The eggs hatch in the stomach or intestine and the larvae are passed in the feces. After a period of development in moist earth or water, the larvae are ingested by the host and pass to the intestine. There, they burrow through the intestinal wall into the lymph nodes and are carried to the lungs, where they mature into the adult stage.

(c) Damage - In heavy infestations, there can be mechanical blockage of the lungs, causing a collapse of the infected area. This furnishes an ideal location for the invasion of other organisms. They can also cause blockage of the windpipe and bronchia.

(d) Symptoms - Coughing is the first indication of this parasite, and it is accompanied by faster and more forceful breathing. In severe cases, the animal breathes with its mouth open and its tongue protruding. The animal is reluctant to move, usually develops a fever, goes off feed and water, and becomes gaunt.

(e) Control - Sanitation and pasture rotation are the best control practices. Chemical control is relatively effective.

c) Tapeworms - Tapeworms are far less important than roundworms.

1) Broad tapeworm

(a) Hosts - The broad tapeworm is a parasite of all classes of livestock, as well as humans.

(b) Life cycle - The adult lives in the small intestine, where it can reach a length of 10' or more. Tapeworm segments containing eggs break off continuously and pass out in the feces. The eggs are eaten by the oribatid mite, which lives in grass and weeds and serves as an intermediate host. The eggs develop in these mites, then are eaten by livestock and hatch in the small intestines. They feed on foodstuff eaten by the animal and grow to maturity.

(c) Damage - There is no physical damage to the host. However, the tapeworm is in competition with the host for foodstuff.

(d) Symptoms - Unthriftiness, loss of weight, diarrhea, and emaciation are the major symptoms.

(e) Control - Chemicals can rid the host of tapeworms.

2) Beef tapeworm - Although not a serious cattle parasite, it is a serious parasite of humans.

(a) Host - Although the beef tapeworm is a parasite of cattle, humans are the necessary intermediate host.

(b) Life cycle - Adult beef tapeworms only live in humans and can reach a length of 25'. The eggs contaminate the feed of cattle and pass down into the intestines. There, the eggs hatch out, bore through the intestinal wall and lodge in a muscle, causing a cyst. Beef affected by these cysts are called measly beef. The parasite is then passed to humans when infected, undercooked beef is eaten.

(c) Damage - There is little economic damage to cattle by the parasite; however, it is a problem for humans.

(d) Symptoms - There are almost no visible symptoms in beef cattle except in the carcasses of slaughtered animals.

(e) Control - Since humans are the necessary intermediate host and the beef tapeworm is transferred through the meat, the best control is eating only well-cooked beef. People who raise or work around cattle should have themselves checked regularly.

3) Pork tapeworm - This tapeworm is the same as the beef tapeworm, except that the larvae live in the muscle tissue of pork.

d) Liver fluke

1) Hosts - The liver fluke is a parasite of cattle, sheep, goats, and humans. It is especially damaging to young animals.

2) Life cycle - The adult lives in bile ducts, where eggs are laid and pass down into the intestines and out in the feces. Eggs must land in water to hatch. The larvae that hatch from these eggs swim about seeking a snail, which is necessary for completing the liver fluke's life cycle. The larvae develop for a period in the snail, then emerge and attach to plants along the water. Livestock eat the water plants and become infested. The young flukes pass to the intestines and burrow through the abdominal cavity and into the liver, where they live principally on blood. Egg production begins about three months after entering the animal.

3) Damage - The fluke causes irritation, thickening of the bile duct, and fibrosis of the liver, making it unfit for human consumption.

4) Symptoms - The usual symptoms are anemia and weight loss. Highly infested animals might die.

5) Control - Pasture rotation and using water troughs help in control. The use of chemical treatment will kill adult flukes in the animal. Control of snails will break the cycle, but it is difficult to do.

3. Relate external parasites of poultry. Why do they differ from other livestock? Ask about products used to control parasites. Mites (including common chiggers) can be found on humans and other mammals.

What are the external parasites of poultry, their symptoms, and treatments?

a) Poultry producers lose millions of dollars annually to damage caused by external parasites. These parasites transmit pathogens or kill birds, decrease egg production, increase feed costs, reduce weight gains, and lower carcass quality.

b) Lice
   1) Lice are more abundant in summer than in winter.
   2) Lice are permanent parasites of their hosts. They spend all life stages on the same bird. Sometimes, they will pass from one bird to another, particularly from an older bird to a younger bird.
   3) Although lice eggs are laid singly, they can be abundant enough to form dense clusters on the fluffy area of contour feathers of badly infested chickens.
   4) Eggs cemented to the bird's feathers are oval, white, and sometimes beautifully ornamented with fine spines. Eggs hatch in a few days or weeks.
   5) Young nymphs immediately begin running about and feeding on the host.
   6) After a few weeks, they gradually become adult sized in form and color.
   7) All lice infecting poultry are sucking and chewing types.
   8) Lice irritate, cause weight loss, reduce egg production, decrease carcass quality, and can even kill birds.
   9) Several species of lice attack poultry. These include: body lice, head lice, wing lice, and fluff lice.

c) Mites
   1) Mites vary in size and structure. Poultry are susceptible to many types of mites.
   2) Mites usually occur on or under the bird's skin or feathers. A few can exist in body tissues, feather quills, or nasal and respiratory passages such as the air sac.
   3) Mites feed by piercing the bird's skin or tissue, sucking blood or body fluids, or by biting bits of skin or feathers.
   4) Mites slow the growth of birds, reduce egg production, lower vitality, damage plumage, and even kill birds.
   5) Much of the injury, consisting of constant irritation and loss of blood, is unapparent unless one examines the bird.

d) Ticks
   1) Several species of ticks affect poultry. These include the fowl tick, Lone Star tick, and Gulf Coast tick.
   2) The tick is a bloodsucker and injures poultry by transmitting disease, causing weight loss, lowering egg production, and causing skin blemishes that reduce market value.
   3) Ticks are difficult to eradicate. Houses and surrounding areas require thorough pesticide treatment.

e) Mosquitoes transmit poultry diseases, including malaria and fowlpox.

f) Many pesticides exist to control external parasites of poultry. Because the list of approved material changes rapidly, consult a poultry specialist for a recommendation.

g) Besides applying pesticides, producers can apply good management practices to their operation. Poultry houses and surrounding areas should be free of foreign materials, including manure and stagnant water.

4. Discuss internal parasites of poultry. Discuss similarities with parasites learned previously. Ask students about treatments.

What are the internal parasites of poultry, their symptoms, and treatments?

- a) Various worms are major internal parasites of poultry. The number of worms that occur in any given bird depends upon the number of infectious eggs that the bird ingests. Worms do not multiply within the host bird.
- b) Roundworms
  - 1) Large roundworms
    - (a) Hosts - Chickens, turkeys, ducks, geese, and pigeons are susceptible to large roundworms.
    - (b) Life cycle - The large roundworm has a simple and direct life cycle. The female lays thick, heavy-shelled eggs in the bird's intestines. The eggs are expelled in the feces. Poultry ingest the eggs, the eggs hatch, and the larvae develop into mature worms to complete the life cycle.
    - (c) Symptoms and damage - Heavily infested birds exhibit droopiness, emaciation, and diarrhea. Very heavy infestations result in death. Primary damage is reduction in efficiency.
  - 2) Cecal worm
    - (a) Hosts - These exist in the ceca of chickens, turkeys, and other birds.
    - (b) Life cycle - A cecal worm's cycle is similar to that of the large roundworm.
    - (c) Symptoms and damages - This common worm parasite does not affect the bird's health seriously. There are no marked symptoms or pathology occurrences due to the presence of cecal worms.
  - 3) Capillary worms
    - (a) Hosts - Capillary worms occur in the bird's crop and esophagus.
    - (b) Life cycle - The life cycle is direct or bird-to-bird. Worms lay their eggs in the bird's feces. Poultry eat the infected eggs.
    - (c) Symptoms or damage - The worm produces a catarrhal inflammation and sometimes causes hemorrhaging. The bird's intestinal lining might erode extensively and result in death. Heavy infestations, especially in houses with deep litter, reduce growth, egg production, and fertility of birds.
- c) Tapeworms
  - 1) These differ from roundworms because they are flat, ribbon-like, and segmented. They also differ from other worm parasites by having both male and female sexual organs on each segment.
  - 2) Worms attach to the intestinal lining by suction cups located on the worm's head.
  - 3) Symptoms of tapeworm infestation in poultry include weakness, unthriftiness, and poor growth. Diarrhea develops in some cases.
  - 4) Tapeworms affect young birds more severely than older birds.
- d) Flukes
  - 1) Flukes are leaf-like flatworms that affect various parts of a bird's body.
  - 2) Flukes do not cause significant losses in poultry.
- e) Prevention and control of worm infestations involves more than treatment. Proper diet, sanitation, and medication are essential.
  - 1) Poultry should receive feed rations adequate in vitamins A and B complex. Rations lacking these vitamins make poultry more susceptible to worm infestations.
  - 2) Sanitation practices are essential to prevention and control of worms. Remove poultry litter regularly. Avoid overcrowding birds.
  - 3) Treat infected birds with commercial drugs.

F. Other activities

Collect several feces samples from various species of livestock. Examine the samples under a microscope for types of internal parasites.

G. Conclusion

Proper management and sanitation is the best control measure for both internal and external parasites in all species of livestock and poultry. Proper identification of the parasites leads the way to appropriate prevention and treatment. There are many drugs available commercially to help control parasites.

H. Competency

Describe the major external and internal parasites of livestock.

Related Missouri Core Competencies and Key Skills

10A-6: Classify species associations into types of symbiosis: commensalism, mutualism, and parasitism

I. Answers to Evaluation

1. a, b, d-f, i, j (question worth 10 points)
2. a, b, e, f, i, j (question worth 10 points)
3. a, e, f, j (question worth 10 points)
4. e-h, j (question worth 10 points)
5. e
6. b
7. d
8. g
9. j
10. a
11. i
12. h
13. c

UNIT IV - ANIMAL HEALTH Name______________

Lesson 6: External and Internal Parasites Date______________

EVALUATION

Complete the following multiple answer questions by marking the correct answers.

1. Select the host, life cycle, damage, symptoms, and control characteristics for flies.

____ a. Flies can be controlled by ear tags containing insecticides.
____ b. Flies can be controlled by medicated feed additives.
____ c. Eggs hatch in approximately 12 hours.
____ d. A symptom is excessive watering of the host's eyes.
____ e. A symptom is loss of weight.
____ f. Fly damage is caused by diseases that are transmitted.
____ g. Cattle are exclusive hosts.
____ h. Hogs are exclusive hosts.
____ i. Damage occurs by annoying biting and sucking of blood.
____ j. For control, chemical rotation is recommended.

2. Mark the host, life cycle, damage, symptoms, and control characteristics for screwworms.

____ a. A symptom is an unpleasant odor.
____ b. Enlargement of an existing wound is a symptom.
____ c. Cattle are exclusive hosts.
____ d. Hogs are exclusive hosts.
____ e. Screwworms can be controlled by medicated sprays.
____ f. The adult screwworm is called the blowfly.
____ g. Larvae feed on living flesh for 10-12 days.
____ h. Larvae pupate in the animal.
____ i. Damage can result in the animal's death.
____ j. Permanent damage and weight loss can result.

3. For the broad tapeworm, check the host, life cycle, damage, symptoms, and control characteristics.

____ a. Humans can be a host.
____ b. Cattle are exclusive hosts.
____ c. Hogs are exclusive hosts.
____ d. Poor quality hides are a result.
____ e. A symptom is weight loss.
____ f. Diarrhea is a symptom.
____ g. Eggs hatch in the large intestine of the animal.
____ h. Eggs hatch in the animal's stomach.
____ i. Eggs are released from the body through urine.
____ j. Eggs are released from the body through feces.

4. Select the host, life cycle, damage, symptoms, and control characteristics of the lungworm.

____ a. Cattle are exclusive hosts.
____ b. Hogs are exclusive hosts.
____ c. Humans can be hosts.
____ d. Eggs hatch in the lungs.
____ e. Eggs hatch in the stomach or intestine.
____ f. Pasture rotation is a good form of control.
____ g. Good sanitation practices help control lungworms.
____ h. A symptom is coughing.
____ i. Diarrhea is a symptom.
____ j. Windpipe blockage can be a result.

Match the parasite on the right with the symptom on the left.

5. ____ The animal rubs and scratches its body excessively.

6. ____ A hard-to-heal, crusty sore is apparent in the eye's corner nearest the bridge of a horse's nose.

7. ____ White, oval eggs are cemented to the chicken's feathers

8. ____ Hair falls out and the skin becomes rough.

9. ____ Anemia, unthriftiness, and scours are apparent.

10. ____ Chickens have inflammation and hemorrhaging of mucous membranes.

11. ____ There is an unpleasant odor and enlargement of a wound.

12. ____ The horse rubs its tail excessively, and white, scaly deposits appear on the tail.

13. ____ There is a visible swelling on the back of cattle where these are present.

a. Capillary worm
b. *Habronema*
c. Heel fly
d. Lice
e. Louse
f. Lungworm
g. Mite
h. Pinworm
i. Screwworm
j. Stomachworm

UNIT IV - ANIMAL HEALTH

Lesson 7: Quality Assurance Programs

Objective: The student will be able to understand and describe animal health quality assurance programs.

Study Questions

1. **What is the pork quality assurance program?**
2. **What is the beef quality assurance program?**
3. **What is the dairy quality assurance program?**

References

1. Student Reference

Lesson 7: Quality Assurance Programs

TEACHING PROCEDURES

A. Review

Review previous lesson on external and internal parasites of livestock.

B. Motivation

How safe are the foods we eat? How are the foods we eat regulated? Livestock associations have developed programs to ensure quality in animal products. Quality animal products start on the farm with the producer. Producers should be responsible for their products. This responsibility will instill consumer confidence in animal products and (hopefully) increase demand for these products.

C. Assignment

D. Supervised study

E. Discussion

1. Ask students if they know what the pork quality assurance program is and how it helps the swine industry.

What is the pork quality assurance program?

a) The pork industry's Quality Assurance Program has three levels. A swine producer interested in the Quality Assurance Program can request information about levels I and II from the National Pork Producers Council. The producer must read the information in the booklet and then take the evaluation at the end. Once the understands the idea of quality assurance, he/she sends the self-addressed card back to the NPPC, which sends the level III booklet. The producer must follow guidelines in the level III booklet to qualify for the "Quality Assurance Program."

b) Level III: Ten critical control points for "Quality Assured Pork Production"

   1) Establish an efficient, effective herd health management plan. A swine producer should provide a clean, healthy environment, as much as possible. A checklist helps ensure management practices are in line for a healthy herd. The herd health management plan also sets up a vaccination program and compares the herd to recent trends in the swine industry. The herd health management plan should be completed in the presence of the presiding veterinarian.

   2) Establish a valid veterinarian/client/patient relationship. The veterinarian/client/patient relationship exists when the following conditions are met:

      (a) When the client or swine producer agrees to the instructions provided by the veterinarian on animal health and medical treatments.

      (b) Veterinarian has sufficient knowledge of client's livestock to make proper judgments on medical treatments.

      (c) Veterinarian is readily available for follow-up evaluation on infected livestock to observe any adverse conditions that still exist.

   3) Store all drugs correctly. Always follow label instructions and pay close attention to expiration dates. If the label reads, "use the entire bottle," do so or discard. Store leftover medications in a cool, dry, and dark place, preferably in a

refrigerator. A pick-up dashboard is unacceptable. Clean syringes and discard used needles. Do not store medications in syringes. Keep medications out of reach of children. Keep water or feed additives dry to prevent caking or clumping.

4) Use only FDA-approved OTC (over-the-counter) or Rx (prescription) drugs with professional assistance. Remember, prescription medications can be administered only by a licensed veterinarian. Over-the-counter medications can be administered by anyone after carefully reading label directions. A swine producer must use only FDA-approved drugs whether the drugs are prescription, extra label, or OTC medications. (Extra label medications require extra instructions from the vet.) The producer must follow the guidelines on dosage, withholding times, mixing, safety, and efficacy. Producers are discouraged from buying unapproved FDA medications and drugs from uninformed suppliers.

5) Administer all injectable drugs and oral medications properly.
    (a) A swine producer must know the following about administration of injectables:
        (1) Use smallest recommended needle to lessen stress, minimize tissue and skin damage, and reduce leakage.
        (2) Know the four types of delivery systems for injectable medications:
            i) Intramuscular (IM): in the muscle
            ii) Subcutaneous (SQ): under the skin
            iii) Intraperitoneal (IP): in the abdominal cavity
            iv) Intravenous (IV): in the vein
        (3) Are injections ever given in the muscle of the ham?
        (4) Are syringes adjusted correctly to give proper dosages?
        (5) Are label directions followed for quantity of medication and site selection?
        (6) Are animals restrained to prevent needle breakage and inappropriate dosages?
    (b) A swine producer must know the following about administering water medications:
        (1) When are water medications used?
        (2) How are medicators calibrated?
        (3) How often are medicators calibrated?
        (4) Where are medications stored?
        (5) How are lines flushed, if medications are used?
        (6) Are medications mixed daily, and is consumption monitored?
        (7) What is the recording system for water medications?
    (c) If the producer cannot answer the previous questions correctly, he/she must seek assistance from the veterinarian.

6) Follow label instructions for use of feed additives. If a swine producer cannot answer the following questions correctly, he/she should seek assistance from the veterinarian.
    (a) When is the last time the mixer or scale was calibrated? What is the period the owner's manual recommends?
    (b) Are written records kept on calibration dates?
    (c) When is the last time a feed analysis was done to check mixer accuracy?
    (d) How often is the mixer checked for wear?
    (e) How often is the mixer or mill cleaned?
    (f) How are spills of medicated feeds handled?
    (g) Is the mixer flushed after mixing medicated feeds?
    (h) How are feed additives stored?
    (i) Are label directions and withdrawal times followed carefully?

7) Maintain proper treatment records and adequate identification of all treated animals. A swine producer is responsible for keeping accurate records on all

health-related events associated with livestock. These records must include the identification of animals, what medications were administered, times treated, and withdrawal times.

8) Use drug residue tests when appropriate. The following situations should be considered for residue testing of swine:
   (a) Sows culled directly from the farrowing house for selling or marketing
   (b) Animals that received extra label medications
   (c) Swine shown at fairs or livestock shows
   (d) Pigs sold to individuals for roasting or slaughter at private slaughter houses
   (e) Newly purchased animals entering the herd, since it is rare to get treatment records on newly purchased animals
9) Implement employee/family awareness of proper drug use. Swine producers, employees, and family members who are involved with administering medications should be educated on proper administration techniques and product label information. Remember, the swine producer is ultimately responsible for those hogs!
10) Complete quality assurance checklist annually. The swine producer must complete the "Quality Assurance Checklist" annually with residing veterinarian. Consider this checklist as a minimum for swine health programs. This checklist assesses one's attitude, knowledge, and commitment to the pork industry.

2. Ask students if they know what the beef quality assurance program is and how it helps the cattle industry.

What is the beef quality assurance program?

a) Missouri Beef Quality Assurance Program is different from pork and dairy programs. The Missouri beef producers have set up a code of ethics for producing beef in Missouri. They have also set up beef management practices that should be followed by beef producers. Instead of 10 critical control points, the Missouri beef producers have set up five "beef tips" that producers should follow to ensure quality beef products. These tips follow.
b) When processing cattle
   1) Handle cattle in a way that minimizes bruising when administering injections.
   2) Avoid injecting cattle during wet weather to prevent contaminants from entering the injection site. Make sure injection site is dirt- and manure-free.
   3) Avoid using disinfectants when using any modified live virus product.
   4) Consider needle size when administering medications. Use smallest needle possible to prevent abscesses.
   5) Wet down work area around the chute to reduce dust or other foreign materials. Secondary infections could result from these materials entering the body at injection sites and open incisions.
   6) Select injection sites carefully. Consider injecting medications in the neck or lower thigh to prevent loss of expensive cuts of meat and market docks.
   7) Consider the volume of medication injected at one site. There are limitations on the amount given at a selected injection site.
   8) Know the differences between intravenous (IV), intramuscular (IM), and subcutaneous (SQ) injections. Inject these medications appropriately and follow label directions.
   9) Always place implants properly to avoid excess trimming of meat.
   10) Keep the working area, equipment, and employees clean to avoid any secondary infections when working with cattle.

c) Current Good Manufacturing Practices
  1) Buildings, grounds, work and storage areas, and equipment should be routinely maintained, metered, cleaned, and properly stored to ensure purity and intended potency.
  2) The manufacturer must keep accurate records of all laboratory tests done on product testing.
  3) Proper storage for different medications should be designed and maintained. Make sure proper clean-out procedures are followed with equipment to prevent contamination of products.
  4) Adequately label products to prevent mix-ups and assure correct labels are used on medicated feed.
  5) Keep production records on formulation, mixing dates, and shipping dates to ensure quality assurance.

d) Violations and inspections - Route of communication if residue is found
  1) If a residue is detected in an animal, the inspector will report the finding to the USDA's Food Safety and Inspection Service. A case number and identification number are assigned to the owner of the cattle. Then, the producer will be asked questions about the incident and why the animal(s) tested positively.
  2) Every time the producer ships animals to market, the USDA office should be notified of shipments. This monitoring will continue until the USDA office is satisfied that the occurrence will not happen again.
  3) The USDA office reports this incidence to the FDA. If the violation only occurs once, there will probably not be a visit. However, if there are several violations, there will be a visit to the facility. The FDA has the legal right to inspect any facility they want, and the producer's cooperation is critical.
  4) If one does not cooperate with the FDA during their inspection, the FDA can do the following:
    (a) Get a federal court injunction against the facility to halt all further activities.
    (b) Begin civil or even criminal prosecution against a producer for not complying with FDA regulations.
    (c) Seize all cattle that remain at the facility.
  5) Residue violations are critical. Producers must understand label directions concerning residue withdrawal times or pay the consequences.

e) Record keeping and inventory control
  1) Beef producers must keep accurate records on all aspects of animal health. To maintain market share and consumer confidence, producers must prove, through effective documentation, that they have tight control over risk factors.
  2) Animal health product inventories are also important for beef producers to control. Knowing the amounts of medications and the amounts used are vital to maintaining a tight control over risk factors.

f) Feed ingredients quality control - A beef producer must be aware of implications associated with residues found in feed ingredients. If a producer buys a load of medicated feed from a supplier and the cattle have a residue violation, who is responsible? If the producer does not have accurate records verifying that the load of medicated feed was received on a certain date, the producer is responsible. If the producer can produce accurate records of all incoming feed ingredients, the producer can pass the liability to the supplier.

299

3. Ask students if they know what the dairy quality assurance program is and how it helps the dairy industry.

What is the dairy quality assurance program?

a) Ten critical control points for "Quality Assured Dairy Production"
   1) Preventive herd health management program - A dairy producer should maintain the herd in a clean, healthy environment, as much as possible. The nutritional program should meet growth, maintenance, and lactation needs of animals. A producer should have the veterinarian implement a health program that encompasses preventive medical procedures and monitoring of reproductive status of breeding stock. Good management practices and health programs keep animals producing efficiently; therefore, they are less depends on medical therapy.
   2) Establish a valid veterinarian/client/patient relationship. The veterinarian/client/patient relationship exists when the following conditions are met.
      (a) The client or dairy producer agrees to the instructions provided by the veterinarian on animal health and medical treatment judgments.
      (b) Veterinarian has sufficient knowledge of client's livestock to make proper judgments on medical treatments.
      (c) The veterinarian is readily available for a follow-up evaluation on infected livestock to observe any adverse conditions that still exist.
   3) Dairy producers should use FDA-approved drugs, whether they are prescription or over-the-counter drugs. The producer must follow label guidelines on dosage, withholding times, mixing, safety, and efficacy.
   4) All drugs labels comply with "Grade A" milk control labeling requirement.
      (a) Over-the-counter drugs used by the dairy producer must have the following requirements specified on the label.
         (1) The manufacturer's label with indications for use on lactating cows and withholding time
         (2) The manufacturer's label with indications for use on non-lactating cows
         (3) If used according to label directions, no further instructions are needed.
      (b) Prescription drugs used by the dairy producer must have the following requirements specified on the label.
         (1) The prescribing veterinarian's name and address, as well as the manufacturer's label indicating milk withholding time on lactating cows.
         (2) The prescribing veterinarian's name and address, in addition to the manufacturer's label indicating use for non-lactating cows.
         (3) Prescription drugs are given by the veterinarian, and the medication should be used up totally. There shouldn't be any left over; if there is, return it to the vet. It should not be stored at the producer's facility.
      (c) Extra label drugs used by the dairy producer must have the following requirements specified on the label.
         (1) The veterinarian's name and address
         (2) Active ingredient
         (3) Directions
         (4) Cautionary statements as necessary
   5) All drugs are stored according to "Grade A" milk control labeling requirements. All drugs used in a dairy operation must be stored properly so they do not contaminate the milk supply, equipment, or utensils. Drugs used for lactating animals must be stored separately from drugs used for non-lactating animals. Drugs for lactating animals must be labeled for "lactating animals" and include the name and address

of the veterinarian if it is a prescription drug. Drugs for non-lactating animals must be labeled for "non-lactating animals."

6) All drugs are administered properly, and treated cows are properly identified. Before administering or dispensing drugs for any animal, a producer must consider the following.
   - (a) What FDA drugs are approved for all classes of cattle on the farm? (Use label.)
   - (b) Follow proper dosages.
   - (c) Follow approved routes of administration.
   - (d) Be familiar with and follow withholding times.

7) Treatment records are properly maintained, and treated animals are adequately identified. A producer is responsible for keeping accurate records on all health-related events associated with animals. These records must include the identification of animals, what drugs were administered, times treated, and withholding times.

8) Proper drug residue testing capabilities are readily available to producers for on- and off-farm usage. Producers must test milk and urine by appropriate tests for best results.
   - (a) A dairy producer must consider the following factors to prevent drug residue from entering the milk supply or the slaughter residue testing.
     - (1) Testing milk from sick animals that have received medication to detect any drug residue. Remember, withholding times on labels are based on healthy animals, so sick animals may have longer withholding times.
     - (2) Testing milk on animals that have been administered extra label drugs, because extra label drugs officially do not have withholding times.
     - (3) Testing dry animals returning to the milking herd that have been administered any type of drug during dry period
     - (4) Testing any newly purchased lactating animals entering the herd, since it is rare to get treatment records on newly purchased animals
     - (5) Testing the urine of any culled animals or calves weaned from treated cows headed for the sale barn. Urine testing detects any drug residues present in the animals. Calves can be infected by drinking milk from a treated cow.
     - (6) Urine or milk testing on animals intended for slaughter to ensure no residue violations during slaughter
   - (b) Precautions and misuses of residue testing
     - (1) NEVER use residue testing to shorten withholding times.
     - (2) NEVER test bulk tank milk to test milk from individual cows. Treated cows should be tested individually, not with the population.
     - (3) NEVER add milk that has tested residue-positive to the bulk tank to dilute it.

9) Employees must show awareness and knowledge of proper drug use and methods to avoid marketing adulterated products. Producers and employees who are involved with administering medications should be educated on proper administration techniques and product label directions.

10) The dairy producer must complete an annual "Quality Assurance Checklist" with the residing veterinarian. Consider this checklist as a minimum for dairy health programs. Each dairy operation should be customized to fit the "Quality Assurance Checklist."

301

F. Other activities

1. When preparing to teach the lesson, some extra preparation might be needed. Possessing the actual assurance programs for each livestock class will greatly improve the presentation on this lesson. Most assurance programs have printed work sheets and checklists for producers to fill out. These work sheets and checklists would add another dimension to the lesson. Use the following addresses to write for information about quality assurance programs.

   a) National Pork Producer Council
   PO Box 10383
   Des Moines, IA 50306
   515/223-2600
   b) Missouri Cattlemen's Association
   PO Box 315
   Ashland, MO 65010
   573/657-2169
   c) Dairy Quality Assurance Center
   801 Shakespeare Box 497
   Stratford, IA 50249
   515/838-2793

2. Teachers can request "Handle with Care" video from Missouri Cattlemen's Association. The tape talks about quality assurance in beef and is 20 minutes in length.

3. Show the video, *Cattlemen Care About Beef Safety* (12 minutes, AG video 190), available from the Missouri Vocational Resource Center.

G. Conclusion

Quality assurance programs help alleviate consumer apprehension about medication usage, placements of injections, drug residues, and environmental conditions. Producers need to make a conscious effort to reevaluate procedures and practices to realign them with these program guidelines. Student awareness of these programs will reenforce the importance of quality production and give them the tools required to defend the industry against opposition or misinformation.

H. Competency

Describe animal health quality assurance programs.

I. Answers to Evaluation

1. b
2. d
3. c
4. b
5. d
6. c
7. d
8. b
9. a
10. b, d, e (question worth eight points)
11. a, d, e, f (question worth eight points)
12. a, d, e, f (question worth six points)

UNIT IV - ANIMAL HEALTH

Lesson 7: Quality Assurance Programs

Name______________

Date______________

EVALUATION

Circle the letter that corresponds to the best answer.

____ 1. Rx stands for what type of medication?

a. Extra label medication
b. Prescription medication
c. Unapproved FDA medication
d. Over-the-counter medication

____ 2. OTC stands for what type of medications?

a. Extra label medication
b. Prescription medication
c. Unapproved FDA medication
d. Over-the-counter medication

____ 3. Where are IM injectable medications given?

a. In the vein
b. Under the skin
c. In the muscle
d. In the abdominal cavity

____ 4. Where are SQ injectable medications given?

a. In the vein
b. Under the skin
c. In the muscle
d. In the abdominal cavity

____ 5. Where are IP injectable medications given?

a. In the vein
b. Under the skin
c. In the muscle
d. In the abdominal cavity

____ 6. The Pork Quality Assurance program has how many levels?

a. 1
b. 2
c. 3
d. 4

____ 7. How often should the "Quality Assurance Checklist" be completed by the producer and veterinarian?

a. Every three months
b. Every six months
c. Every nine months
d. Once a year

____ 8. How many critical control points are there in the Pork Quality Assurance Program?

a. 5
b. 10
c. 15
d. 20

____ 9. What should a producer do to reduce tissue and skin damage, leakage, and stress with injectable medications?

a. Use the smallest recommended needle.
b. Use the largest recommended needle.
c. Inject in the muscle.
d. Inject under the skin.

Complete the following multiple answer questions.

10. A veterinarian/client/patient relationship exists when which conditions are met?

____ a. When producer makes all decisions on health-related events of livestock
____ b. When the veterinarian has sufficient knowledge of producer's livestock
____ c. When producer stores all medications properly
____ d. When veterinarian is readily available to make a follow-up evaluation on livestock
____ e. When producer agrees to follow instructions provided by veterinarian on medical judgments on livestock
____ f. When producer agrees to follow instructions provided by a fellow producer
____ g. When the veterinarian's assistant makes a suggestion on medical treatments
____ h. When producer has sufficient knowledge on his/her livestock

11. Check the appropriate factors that are required on extra-label medications.

____ a. Name and address of prescribing veterinarian
____ b. Producer's name and address
____ c. Producer's telephone number
____ d. Active ingredient
____ e. Cautionary statements
____ f. Directions
____ g. Animal's identification number
____ h. Animal's body weight

12. Mark statements that are true of the Missouri Beef Quality Assurance Program.

____ a. Based on a code of ethics for producers
____ b. Includes 10 critical control points
____ c. Uses a checklist as a minimum for health programs
____ d. Includes injection guidelines to reduce infection risk
____ e. Emphasizes drug withdrawal times to avoid residue problems
____ f. Requires feed ingredient record keeping

MISSOURI AGRICULTURAL EDUCATION

10-4005-S

STUDENT REFERENCE

Animal SCIENCE

In cooperation with Agricultural Education
Department of Practical Arts and
Vocational-Technical Education
College of Education and
College of Agriculture, Food and Natural Resources
University of Missouri - Columbia

In cooperation with
Agricultural Education Section
Division of Vocational and Adult Education
Department of
Elementary and Secondary Education
Jefferson City, Missouri

Available from:

Instructional Materials Laboratory
8 London Hall
Columbia, MO 65211
800/669-2465 or 573/882-2883

Development of this product was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, information or opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

Student Reference

ANIMAL SCIENCE

Writer:
Andy Baker
Instructional Materials Laboratory
University of Missouri-Columbia

Consulting Editor:
Richard E. Linhardt
Agricultural Education
University of Missouri-Columbia

Editor and Project Coordinator:
Diane M. Davis
Instructional Materials Laboratory
University of Missouri-Columbia

Volume 28
Number 4

Catalog Number 10-4005-S
February 1996

ACKNOWLEDGMENTS

Recognition is given to advisory committee members for providing their valuable time and suggestions in developing this year-long unit for the 11th and 12th grade agriculture students. The committee consisted of educators Terry Jenkins, Chuck Miller, Tom Strain, and Kyle Whitaker; industry representatives Roger Eakins and Kent Haden; and Jim Bellis of the Department of Elementary and Secondary Education.

Portions of Unit II (Lessons 3, 4, and 6), Unit III (Lessons 4 and 6), and Unit IV (Lesson 6) are courtesy of *Agriscience 332: Animal Science* and *Agriscience 332H: Advanced Animal Science*. Our appreciation is extended to the Instructional Materials Service, Texas A&M University.

Thanks is also given to the following University of Missouri-Columbia staff and faculty for their technical reviews and contributions: Ross Cowart, Kevin Keegan, Bill Lamberson, Mark Newcomb, Richard Randle, Jim Spain, Stacey Wilson. Technical reviews and/or contributions were received by C.A. "Tony" Martin and Shaun Sweiger of MFA, Inc., and Melaney Oberdahlhoff McGaugh.

Appreciation is given to the following staff members of the Instructional Materials Laboratory for their efforts in producing this material: Harley Schlichting, Director; Phyllis Miller and Dan Stapleton, Assistant Directors; Leslie Forbes, Graphic Designer; Janice Trimble, Word Processor; Felicia Lathon, Zuaelie Ahmed, Julie Martin, and Becky Tieman, student assistants; and Paul Kliethermes and Rhonda Woody, Press I.

Diane M. Davis, Editor and Project Coordinator
Instructional Materials Laboratory
University of Missouri-Columbia

Richard E. Linhardt, Associate Professor
Agricultural Education
University of Missouri-Columbia

FOREWORD

Development of this *Animal Science* unit is the result of MVATA Teaching Aids Committee suggestions. The unit was developed to enhance curriculum for 11th and 12th grade agriculture students. Depending on local need, an Animal Science course could replace traditional advanced production course(s).

This instructor guide and the corresponding student reference contain 30 lessons grouped into four units: Nutrition, Genetics, Reproduction, and Animal Health. Transparency masters and activity sheets have been included where appropriate. Check the Table of Contents for a detailed listing of lessons. Additional student reference copies can be purchased separately.

In an effort to provide challenging test questions that reduce guesswork, multiple-choice questions with multiple answers have been included in some of the lesson evaluations. When scoring this type of question, each possible response can be worth one point. Of course, it is the teacher's option to increase the weight of a question, if desired.

During the summer of 1981, the Missouri State Board of Education formally adopted the concept of "Instructional Management Systems" (IMS) as a priority for the 1981-82 school year. The Missouri Commissioner of Education described the IMS concept as a practical way of "organizing for excellence" in education. To meet the demand for greater productivity and accountability, the director of Vocational Education applied the elements of IMS to form the Vocational Instructional Management System (VIMS). The VIMS process provides a framework to use in planning and organizing to assure excellence in Missouri's vocational education system by focusing greater attention on the management of teaching and learning.

This guide incorporates the needed component parts to aid agriculture teachers in the implementation of VIMS. For ease of use, performance objectives and competencies have been included at the beginning of the guide, as well as incorporated within each lesson. A competency profile has been provided in the front of the guide for convenient record keeping.

Jim Bellis, Supervisor
Agricultural Education
Department of Elementary and Secondary Education

Terry Heiman, Director
Agricultural Education
Department of Elementary and Secondary Education

TABLE OF CONTENTS

ACKNOWLEDGMENTS ii

FOREWORD iii

Unit I - Nutrition

Lesson 1 - Importance of Animal Nutrition to Agriculture I-1
    Careers in Animal Nutrition
    Nutrition Guidelines
    Feed Tags
    Economic Importance of Understanding Nutrition
    General Functions of Nutrients
Lesson 2 - Livestock Digestive Systems I-5
    Digestive Parts and Functions of Ruminants, Nonruminants and Modified Nonruminants
    Parts and Functions of the Avian Digestive System
Lesson 3 - Energy's Role in Livestock Nutrition I-11
    Basic Functions of Energy
    Carbohydrates and Fats (Lipids)
    Absorption of Carbohydrates and Lipids
    Sources of Energy for Animals
    Deficiency and Toxicity Symptoms
Lesson 4 - Protein's Role in Animal Nutrition I-15
    Functions of Protein
    The Role of Amino Acids in Protein Synthesis
    Essential Amino Acids
    Symptoms of Protein Deficiency
    Sources of Protein
    Determining Which Proteins Should Be Used
Lesson 5 - Minerals' Role in Animal Nutrition I-21
    General Functions of Required Minerals
    Macro-Minerals: Functions, Deficiencies, Interactions, Sources
    Micro-Minerals: Functions, Deficiencies, Interactions, Sources
    Absorption of Minerals in the Body
Lesson 6 - Vitamins' Role in Animal Nutrition I-29
    Classification of Required Vitamins
    Fat-Soluble Vitamin Functions, Deficiencies and Sources
    B Complex Vitamins: Functions, Deficiencies and Sources
    Functions, Deficiencies and Sources of Other Water-Soluble Vitamins
Lesson 7 - Water's Role in Animal Nutrition I-35
    Functions of Water
    Daily Requirements for Water
    Water Toxicity
    Effects of Inadequate Water Supply
Lesson 8 - Environmental Effects on Nutrition I-39
    An Animal's Environment
    Weather's Effects on Nutrition Requirements
    Other Factors Affecting Nutrition Needs
    Temperature's Effect on Feed Requirements and Production Yields

Lesson 9 - Formulating and Balancing Rations I-45
    General Principles in Formulating Rations
    Steps in Balancing a Ration
    Eight Essentials of a Balanced Ration

Unit II - Genetics

Lesson 1 - Importance of Genetics in Agriculture II-1
    Occupations Associated with Livestock Genetics
    Economic Importance of Genetics
    Genetic Selection
Lesson 2 - Basic Building Blocks of Genetics II-7
    How Cells Function
    DNA's Effect on Genetics in Livestock
    RNA's Effect on Genetics in Livestock
Lesson 3 - Animal Cell Division II-13
    Genes and Chromosomes
    Chromosomes in Common Livestock
    Cell Division by Mitosis
    Cell Division by Meiosis
Lesson 4 - Basic Principles of Genetics II-19
    Roles of Genes and Alleles
    Genotypes and Phenotypes
    Dominant and Recessive Traits
    Homogenous and Heterogenous Traits
    Basic Genetic Laws
Lesson 5 - Tools for Genetic Improvement of Beef II-25
    Sire and Female Selection
    Crossbreeding and Hybrid Vigor
    EPDs and How They Are Used
Lesson 6 - Selection Tools for Genetic Improvement of Dairy Cattle II-29
    Selecting Dairy Cows and Heifers
    Sire Evaluation Data
Lesson 7 - Tools for Genetic Improvement of Sheep II-33
    Factors to Consider When Establishing a Sheep Flock
    Crossbreeding Systems and Hybrid Vigor
    Using Performance Data
Lesson 8 - Selection Tools for Genetic Improvement of Swine II-37
    Breeding Stock Selection
    Breeding Systems in Swine
    Other Tools Used in Swine Selection

Unit III - Reproduction

Lesson 1 - Importance of Reproduction in Livestock III-1
    Careers Associated With Livestock Reproduction
    Economic Factors Associated With Reproduction
    Parts and Functions of the Male Reproductive System
    Parts and Functions of the Female Reproductive System
Lesson 2 - Reproductive Hormones III-7
    Female Reproductive Hormones
    Male Reproductive Hormones
Lesson 3 - Reproductive Cycles of Common Livestock III-9
    The Age of Puberty

Estrous Cycle
Spermatogenesis in Livestock
Gestation Lengths
Lesson 4 - Fetal Developmental Stages III-13
Developmental Stages of the Livestock Fetus
Development of Embryo During Incubation
Nutritional Requirements During Pregnancy and Lactation
Lesson 5 - Effects of the Environment on Reproduction III-17
Effects of Nutrition and Body Condition
Effects of the Photo Period
Temperature's Effects
Lesson 6 - Management and Technology in Reproduction III-21
Artificial Insemination
Estrous Synchronization
Products Used for Estrous Synchronization
Embryo Transfer
Sexing Semen
Cloning

Unit IV - Animal Health

Lesson 1 - Importance of Animal Health IV-1
Careers Associated With Animal Health
The Economic Importance of Animal Health
Approval of Animal Health Drugs
Population and Individual Medications
Interstate and Intrastate Regulations
Lesson 2 - Immune System of Livestock IV-5
Causes of Diseases in Livestock
Types of Immunity
Types of Immunizing Agents
Antibiotics
Lesson 3 - Respiratory Diseases Affecting Livestock IV-9
Swine
Cattle
Horses (Equine Family)
Lesson 4 - Diseases of the Gastrointestinal Tract IV-15
Swine
Cattle
Horses
Lesson 5 - Reproductive Diseases in Livestock IV-21
Swine
Cattle
Horses
Lesson 6 - External and Internal Parasites IV-25
External Parasites of Livestock: Their Symptoms and Treatments
Internal Parasites of Livestock: Their Symptoms and Treatments
External Parasites of Poultry: Their Symptoms and Treatments
Internal Parasites of Poultry: Their Symptoms and Treatments
Lesson 7 - Quality Assurance Programs IV-33
Pork Quality Assurance Program
Beef Quality Assurance Program
Dairy Quality Assurance Program

Lesson 1:

Importance of Animal Nutrition to Agriculture

Agriculture is the largest industry in the United States. The total assets of agriculture exceed one trillion dollars, which is equal to approximately 70% of the capital assets of all U.S. manufacturing corporations. The production of livestock is an important part of the total agricultural industry. About one-half of farm cash receipts come from the sale of livestock and livestock products. The cost of feed represents from one-half to more than three-fourths of the total cost of raising livestock. Careful attention to animal nutrition can help reduce feed costs and thus increase the potential profit from livestock.

Careers in Animal Nutrition

More than 20% of the U.S. labor force works in an agriculture-related occupation. Approximately 540,000 are employed in the meat, poultry, and dairy production industry. Careers associated with nutrition are many, and may be directly or indirectly related to nutrition. Careers include: agricultural instructors, livestock producers/farmers, nutrition specialists, feedlot managers/employees, feed sales reps, horse trainers, feed store managers, veterinarians, and nutrition researchers.

Most occupations require a college degree or years of experience. More and more areas are requiring a Master's degree or other advanced degree. Today, most feed sales reps are required to have a college degree.

Nutrition Guidelines

The work of research scientists in agriculture has resulted in greatly improved methods of feeding livestock. Many U.S. Agriculture Experiment Stations conduct feeding trials. Results of these experiments relate to the value of feeds and rations under controlled feeding conditions.

The National Research Council of the National Academy of Sciences in Washington, D.C. develops the requirements for different livestock species. The respective sets of requirements are available in publications specific to each species, such as *Nutrient Requirements of Dairy Cattle*. Sub-committees on each species are formed to review the requirements that were set through years of experimentation. The National Research Council (NRC) revises and/or reviews its requirements every several years to keep up with new information discovered through continuing research.

Feed Tags

Before evaluating feed tags, remember one thing--feed tags do not tell the whole story. Investigate the reputation of the feed company before buying any of their products. Companies that have gained the trust of consumers and stood the test of time are good indications of a quality product. When crude protein percentages are given on a tag, a consumer has no idea what type of protein was used. (State regulations do not require this information.) These proteins could be rapidly soluble, slowly soluble, or bound. Find out as much as you can about a product before buying.

Individual states generally regulate the manufacturing and sale of feeds. However, regulations relating to feed additives are made by the federal government. The Association of the American Feed Control Officials has published the "Uniform State Feed Bill," which is followed by many states when preparing their regulations of feed manufacture and sale. This results in a fairly of uniform state regulations.

Major provisions of most state feed laws, rules and regulations include (1) registration of feed manufacturers; (2) labeling requirements; (3) prohibited acts; (4) definitions of misbranding and adulterations of feed; (5) a schedule of inspection fees and reports; (6) inspection, sampling and analysis procedures, and (7) penalties for violations.

The feed tag found on a bag of commercial feed is important to the livestock producer. It contains information about the content of the feed and its proper use. The format and content of the feed tag are regulated by state laws.

FIGURE 1.1 - Sample Feed Tag

NET WEIGHT 50 LBS.

SUPER COW
16% TEXTURED

GUARANTEED ANALYSIS

Crude Protein, not less than	16.0%
Crude Fat, not less than	3.0%
Crude Fiber, not more than	7.5%

INGREDIENTS

Grain Products, Processed Grain By-Products, Plant Protein Products, Animal Protein Products, Cane Molasses, Salt, Calcium Carbonate, Dicalcium Phosphate, Manganese Oxide, Ferrous Sulfate, Copper Sulfate, Magnesium Oxide, Potassium Chloride, Cobalt Carbonate, Zinc Oxide, Ethylenediamine Dihydriodide, Sodium Selenite, Lignin Sulfonate and Sodium Bentonite (pellet binders), Vitamin A Acetate, D-Activated Animal Sterol (source of Vitamin D-3), Vitamin E Supplement, Niacin Supplement, Dried Lactobacillus Acidophilus Fermentation Products, Zinc Methionine.

FEEDING DIRECTIONS

Feed Super Cow 16% Textured as a high-energy supplement to excellent legume hay or haylage or lush legume-grass pasture when used as the only source of roughage for the lactating cow. Feed 1 lb. of this feed for each 2-3 lbs. of milk produced.

Manufactured by
MFA INCORPORATED
Columbia, MO 65201

378X1F 1WR56244 5624

Generally, the tag contains the following information:

1. Net weight
2. Product name and brand name
3. Guaranteed analysis of the feed
   - Minimum percentage of crude protein
   - Maximum or minimum percentage of equivalent protein from nonprotein nitrogen
   - Minimum percentage of crude fat
   - Maximum percentage of crude fiber
   - Minimum and maximum percentages of calcium and salt
   - Minimum percentage of phosphorus
   - Other minerals
   - Vitamin content
4. When drugs are used as an additive:
   - The word "medicated" must be on the label.
   - The medication's purpose must be stated.
   - Directions for use and precautionary statements must be included.
   - A list of active drug ingredients must be given.

Certain exemptions on labeling are common.

1. No mineral guarantee is needed *if* no label claims concerning minerals are made, *and* the total mineral content is less than 6.5% of the total contents.
2. Vitamin information is exempted when the feed contains no claims concerning vitamins or is not being sold as a vitamin supplement.
3. Crude protein, crude fat and crude fiber guarantees are exempted if the feed is not intended to furnish these substances or if they are a minor part of the total ingredients, i.e., in drug premixes, mineral or vitamin supplements, and molasses.

This general description of feed tag labeling is not intended to be a specific guide for a given state. Instead, the Department of Agriculture in each state establishes committees to set state standards. The feed laws, rules and regulations of each state should be considered to determine specific requirements for that state.

Economic Importance of Understanding Nutrition

As was stated before, agriculture is big business in the United States. About one-half of farm cash receipts come from the sale of livestock and livestock products.

The cost of feed is 50-75% of the total cost of raising livestock. Careful attention to animal nutrition can help reduce feed costs and thus increase the potential profit from livestock. However, the lowest cost feed ration may not be the most profitable. Feeding efficiency and nutrition value must also be considered when selecting rations.

It is estimated that 65-80 percent of the total cost of production in a swine operation is for feed. Poultry feed costs range from 55 percent (layers) to 65 percent (broilers and turkeys) of the total cost. Dairy feed costs range from 50-60 percent of the total cost of milk production. Feed costs for a cattle finishing operation are approximately 70 percent of the total cost of feeding cattle. Feeder lamb feed represents about 50 percent of the total cost of production.

General Functions of Nutrients

An animal uses feed for several purposes. Some are basic to all animals, and some are specific to the purpose of the animal. Basic uses include maintenance, growth, and reproduction. Uses reflecting the purpose of the animal include finishing, fitting for show, production, and work.

Maintenance - A maintenance ration is one that maintains basic life processes without any work or production being done. A maintenance ration must supply (1) heat to maintain body temperature; (2) energy for vital functions and a minimum amount of movement, and (3) small amounts of protein, minerals and vitamins.

Oxidation of food in the digestive tract and of nutrients in the muscles and other tissues produces heat. The rate of oxidation is relatively constant and occurs at a low temperature. An animal at rest must still maintain activity in such vital organs as the heart and lungs, as well as other internal organs. Animals that are standing require a higher rate of oxidation of nutrients than those lying down (because of the muscle tension needed to remain standing). Even more energy is needed when an animal moves around. Maintenance rations for mature animals, except swine and poultry, can be mostly roughages that yield enough heat but are relatively low in energy value.

An animal's maintenance requirement is relative to its body surface and its weight. Some protein is required in the maintenance ration because there is some breakdown of protein in body tissues each day. There is also daily loss of calcium and phosphorus from the body of an animal. For this reason, a small amount of protein in the maintenance ration replaces the loss. Salt and a small amount of vitamins A and D are also needed in maintenance rations for most species of livestock.

Growth (assimilation of tissue) - During the growth period, there is a substantial increase in the size of muscles, bones, internal organs, and other body parts. Animals need nutrients to grow properly so that they will be efficient producers when mature. The full genetic potential of an animal cannot be reached if it is not fed a well-balanced ration during the growing period.

Young, growing animals have more nutritional needs than do mature animals. A shortage of digestible nutrients or net energy during growth will result in slower growth or smaller size when animals mature.

Reproduction - If the livestock producer is to make a profit, animals must reproduce. Poor nutrition is a major contributing factor to reproductive failure. The production of sperm and the quality of semen is influenced by the ration's quality. Males that are too fat may become temporarily or permanently sterile. Rations balanced with the proper nutrients improve fertility.

Finishing - Animals such as beef, swine, lambs, and broilers that are fed for meat need nutrients above the maintenance requirements for fattening. Nutrients for fattening animals come mainly from carbohydrates and lipids in the ration. Unneeded protein may also be converted into body fat.

Fitting for show - Animals being fitted for show purposes are fed a liberal supply of carbohydrates and fats, usually through the addition of more grain in the ration. Mature animals being fitted for show need little additional protein, minerals, and vitamins above the maintenance requirements. However, young and growing animals must be fed more liberal amounts to reach the desired level of finish for show purposes.

Production - The production of milk requires a liberal supply of energy, protein, minerals, and vitamins in the ration. For milk production, the quantity of milk and its fat content influence the amount of nutrients needed above the maintenance level. Wool and mohair have high protein content; therefore, rations for sheep and goats must contain an adequate protein level to meet this production need.

Work - The production of work is limited mainly to horses. Riding and racing require additional nutrients for efficient production. As the amount of work increases, so does the animal's energy requirements. Animals require additional nutrients in relation to the kind of terrain they are on, and whether or not they are in confinement feeding. Also, when animals are on pastures, the distance to feed and water influences the amount of nutrients needed.

Summary

Producers are rarely interested in just maintaining animals, yet the maintenance requirements must be met before animals will provide any productivity. Because of the great impact that nutrition has on the overall success of a livestock operation, it is important to have a basic understanding of animal nutrition.

Credits

Cullison, Arthur Edison. *Feeds and Feeding.* 4th ed. Reston, VA: Reston Publishing Co., 1987.

Gillespie, James R. *Animal Nutrition and Feeding.* 4th ed. Albany, NY: Delmar Publishers, Incorporated, 1987.

Lesson 2:
Livestock Digestive Systems

Livestock digestive systems fall into four basic types: ruminant, nonruminant, modified nonruminant, and avian. A ruminant animal has a four-compartment stomach that aids in digestion of roughages. The nonruminant digestive system is very similar to the human digestive system. It is considered a simple stomach system, which is unable to digest roughage effectively. A modified non-ruminant digestive system is also a simple stomach system, but it has an active cecum that helps digest roughages. The avian digestive system does not have a true stomach; it uses several organs to aid in concentrate digestion.

Digestive Parts and Functions of Ruminants, Nonruminants and Modified Nonruminants

Oral region - The oral region includes the mouth, teeth, and tongue. Three physical processes take place here. Prehension is the process of bringing food into the mouth, which can occur in several ways. Humans use their fore limbs to bring food into their mouth. Livestock take in feed through the mouth, tongue, lips, and teeth.

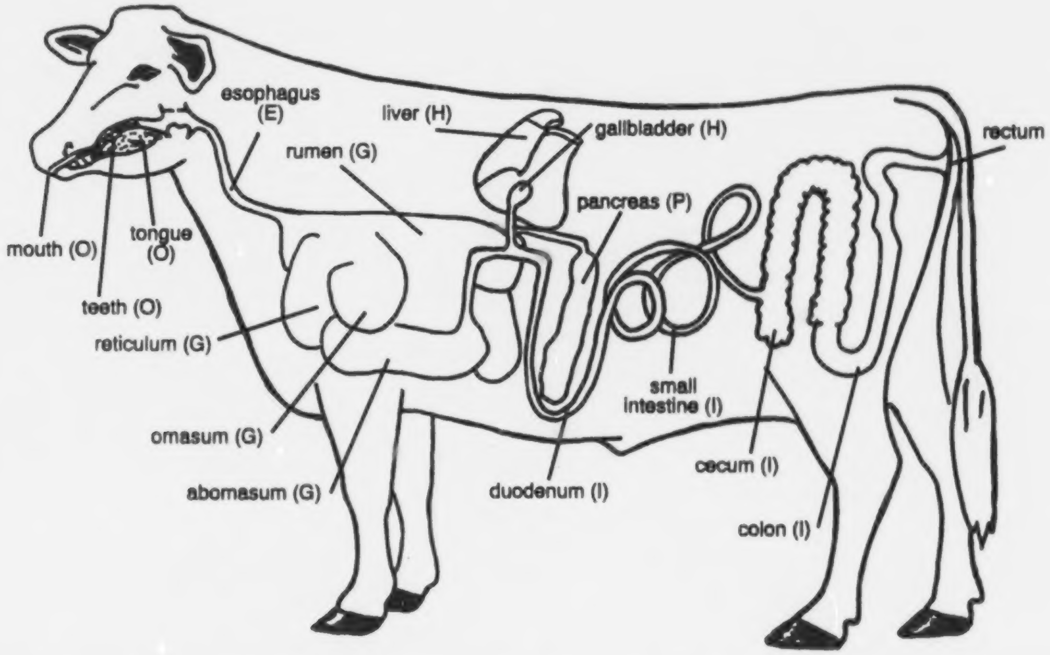
The second process is mastication--the chewing of food once it enters the mouth. Mastication begins by physically tearing and grinding the food into smaller particles. Saliva is also added to food during mastication.

The third process is called deglutition, or swallowing the food, which occurs after saliva is mixed and chewing has taken place. These three physical processes occur in all digestive systems, except the avian's.

Esophageal region - This region includes the esophagus, pharynx, and the larynx. The esophageal region applies to all classes of livestock. At the top of the esophagus is the pharynx, which controls the passage of food, water, and air. When deglutition occurs, the

FIGURE 2.1 - Digestive System Parts of a Ruminant

NOTE: Drawing does not show exact anatomical placement.



larynx closes. This allows the feed to go into the esophagus--not into the respiratory tract. The muscular tube that extends from the mouth to the stomach is called the esophagus.

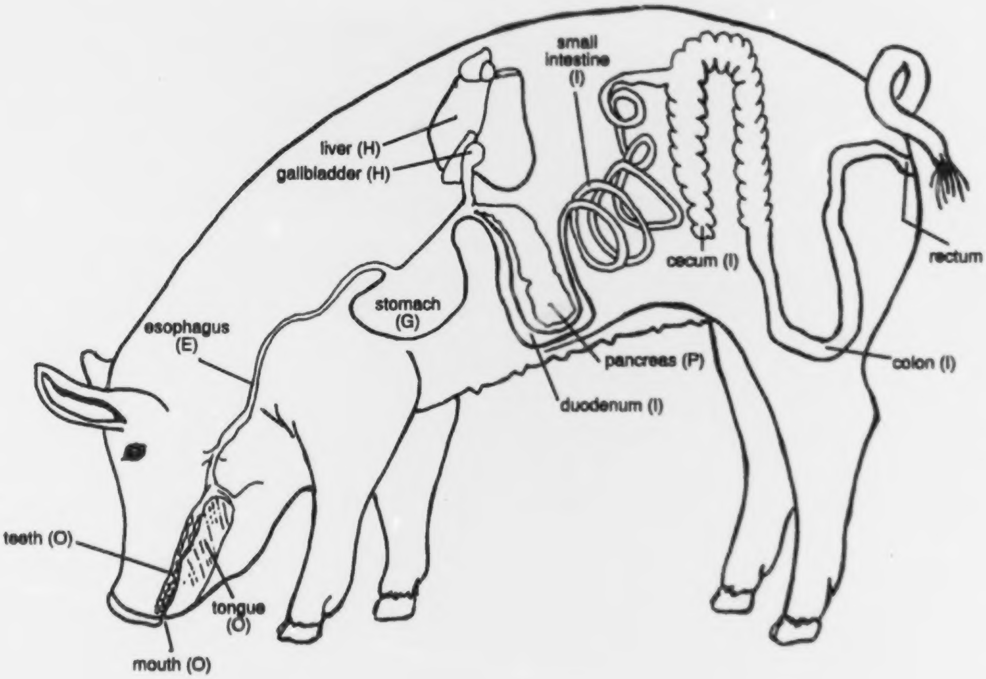
Peristalsis is the coordinated contraction and relaxation of smooth muscles. This process creates a unidirectional movement, which pushes food through the digestive system. For further digestion of food, peristalsis is reversed in ruminants through belching or vomiting. Reverse peristalsis is considered an abnormal function in other digestive systems.

Gastric region - The gastric region in ruminant animals consists of four compartments: the rumen, reticulum, omasum, and abomasum. In the rumen and reticulum area, bacteria and protozoa are present to aid in digestion. These microorganisms digest carbohydrates, and produce carbon dioxide and volatile fatty acids. The fatty acids are then absorbed as a source of energy. Carbon dioxide is released through belching. Once food enters the gastric region, the food is mixed and stirred with water through muscular action in the rumen. Vitamins K, C, and B complex are synthesized in the rumen. Since the vitamins are synthesized, there is no need to supplement these vitamins in the diet if quality feedstuffs are provided in the diet.

The major function of the omasum is to grind the partially digested food further. The omasum also absorbs a small percentage of water from the partially digested food. Finally, the omasum absorbs some of the volatile fatty acids as food passes through the digestive tract.

The abomasum is considered the "true stomach" of the ruminant animal. In the abomasum, digestive juices are added, which contain acids and enzymes that increase the moisture content of the feed. This mixture becomes acidic in nature because of the added acids. This also occurs in nonruminant and modified nonruminant

FIGURE 2.2 - Digestive System Parts of a Nonruminant



animals. Protein is digested here and in the small intestine.

The gastric region for nonruminant and modified nonruminant animals is based on a simple stomach system. With the enzymes and acids present in the stomach, digestion begins on proteins. Fats are partially broken down in the stomach. Carbohydrates move the fastest through the stomach, because digestion occurs in the small intestine.

Pancreatic region - The pancreatic region consists of one organ: the pancreas. It is made up of two glands, the endocrine and exocrine glands. The endocrine gland secretes the hormones insulin and glucagon. These hormones are necessary for digestion in the small intestine. The exocrine gland secretes trypsinogen, which is an enzyme necessary for digestion. Trypsinogen is produced in an inactive form, and then activated in the small intestine. The pancreas serves the same function in all four classes of livestock.

Hepatic region - In this region are two organs: the liver and the gallbladder. The liver is the largest gland in an animal's body. It serves the same purpose in ruminants, nonruminants, and modified nonruminants. The liver is one of the most important digestive organs for all animals, including humans.

The liver provides many physiological functions. It produces bile, which is an essential fluid for lipid (fat) absorption. The liver is used in detoxification of harmful compounds. It also acts as a storage facility for vitamins and carbohydrates. The liver aids in metabolism of proteins, carbohydrates, and lipids. The liver destroys red blood cells so more blood cells can be made. It is used in the plasma proteins and urea formation in all livestock except avians. Polypeptide hormones are deactivated in the liver, as well.

The only function of the gallbladder is to store bile produced by the liver. Gallbladders serve the same purpose in ruminants, nonruminants, and poultry. Some animals do not have a gallbladder (horses, rats, gophers, doves, pigeons, elephants, moose, elk, deer, camels, and giraffes).

Intestinal region - The intestinal region consists of four organs: the duodenum, colon, cecum, and the small intestine. Fats are emulsified in the duodenum. When fats are mixed with bile in the duodenum, they become soluble in water. This process is called emulsification. Once fats are emulsified, they are absorbed into the bloodstream in the small intestine.

Proteins and carbohydrates are broken down further in the duodenum, where the food mixture becomes neutral when alkaline enzymes are added. Bile and pancreatic fluids are added to the partially digested food mixture in the duodenum. The duodenum functions similarly in ruminants, nonruminants, and modified nonruminants. Avians do not have a duodenum.

Except for water and fiber, all nutrients are absorbed into the bloodstream in the small intestine. At this point in digestion, food is broken down enough to be absorbed into the bloodstream and used by the animal. Absorption takes place in the small intestine by hairlike projections called villi. Villi are used to increase the surface area in the small intestine so more nutrients can be absorbed.

Peristalsis occurs in the small intestine so undigested food can be pushed through the colon, cecum and finally through the rectum. The small intestine functions similarly in all classes of livestock, except the avian class.

The cecum functions similarly in all classes of livestock, except poultry. It has a very limited function in nonruminant animals--the storage of microorganisms. In ruminant animals, the cecum absorbs 5-15 percent of the fiber the animal eats. It also stores microorganisms needed for ruminant fiber digestion. The modified nonruminant cecum is much larger than other classes of livestock. It is also very functional. Roughage is totally digested in the cecum in modified nonruminant animals.

The colon functions similarly in ruminant, nonruminant, and modified nonruminant systems. Water is absorbed and fecal formation occurs in the colon. Mucus is added to the fecal matter to provide lubrication. The fecal mixture remains neutral during this process.

Parts and Functions of the Avian Digestive System

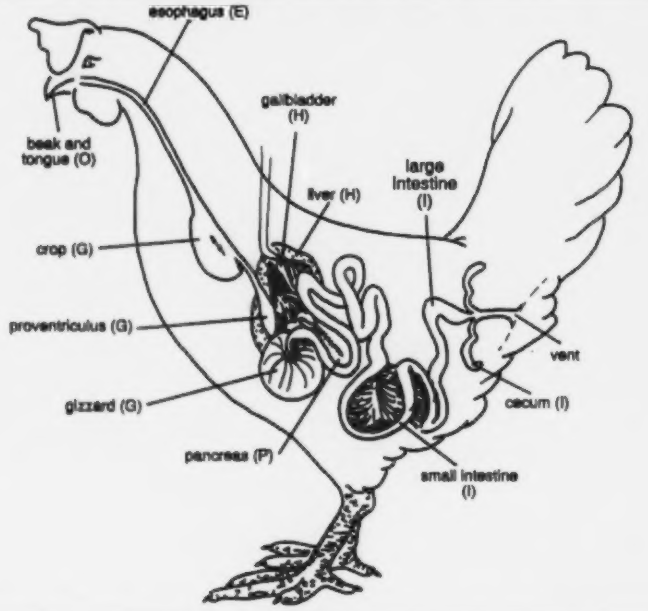
Oral region - Only two physical processes occur in this region. In prehension, the beak and tongue of the bird bring food into the mouth. Deglutition is the process of swallowing. In avians, food goes directly into the mouth and down the esophagus; mastication does not occur.

Esophageal region - This region includes the esophagus, pharynx, and larynx. At the top of the esophagus, the pharynx controls the passage of food, water, and air. When deglutition occurs, the larynx closes. This allows the feed to go into the esophagus--not into the respiratory tract.

The muscular tube that extends from the mouth to the crop is the esophagus. In peristalsis, the coordinated contraction and relaxation of smooth muscles creates a unidirectional movement. This movement pushes food through the digestive system. Reverse peristalsis is considered an abnormal function.

Gastric region - In avians, the gastric region uses both chemical and mechanical processes to aid digestion. Three organs make up the gastric region: the crop, proventriculus, and gizzard. The crop stores food after it enters the body. Mucus is secreted in the crop and added to the food to softens and lubricates it. The food then moves from the crop to the proventriculus, where it secretes gastric fluids and adds these fluids to the slightly digested food. The food then continues on to the gizzard, a muscular organ that mechanically mixes and grinds food. The gizzard acts as mixing machine for gastric fluids and food. Grit, which accumulates in the gizzard, is sometimes added to the diet to aid in digestion. Grit, plus the mixing motion, replace teeth for the grinding and tearing of food.

FIGURE 2.3 - Digestive System Parts of an Avian



Pancreatic region - This region consists of one organ: the pancreas. The pancreas is made up of two glands: the endocrine and exocrine glands. The endocrine gland secretes the hormones insulin and glucagon, which are necessary for digestion in the small intestine. The exocrine gland secretes trypsinogen, an enzyme necessary for digestion. Trypsinogen is is produced in an inactive form and then activated in the small intestine by pH changes.

Hepatic region - The hepatic region consists of two organs: the liver and the gallbladder. The liver is a very important digestive organ and is the largest gland in an animal's body. It serves the same purpose in all classes of livestock. The liver aids in digestion for all animals--including humans.

The liver provides many physiological functions; it produces bile, an essential fluid for lipid absorption. It detoxifies harmful compounds and stores vitamins and carbohydrates. Metabolism of carbohydrates, proteins, and lipids is aided by the liver. It also destroys red blood cells so more blood cells can be made. The liver is needed to form plasma proteins and to deactivate polypeptide hormones.

The only function of the gallbladder is storage of the bile produced by the liver.

Intestinal region - Three physical movements occur in the small intestine which aid in the movement of digested food through the intestinal region: pendular motion, segmentation contractions, and peristalsis. Pendular motion mixes food by shortening and lengthening the intestine. Segmentation contractions are ringlike contractions that mix food at regular intervals. The last movement is peristalsis, the coordinated contraction and relaxation of smooth muscles. The small intestine is the primary organ in digestion and absorption in the avian class. Special enzymes in the small intestine provide an effective and efficient manner of breaking down proteins, lipids, and carbohydrates into particles that can be absorbed.

The ceca is a blind-ended tube found at the junction of the small intestine and the large intestine. Ceca (two or more) is the plural form of cecum. Poultry have two nonfunctioning cecum in their digestive systems.

The function of the large intestine, or colon, is to remove water from digested food for fecal formation. Urinary and fecal materials are mixed in the cloaca before they leave the body through the vent.

Summary

All of these digestive systems use chemical and mechanical processes to help in digestion and absorption.

Credits

Livestock Nutrition and Feeding (Student Manual). 2nd ed. Columbus, OH: Ohio Agricultural Education Curriculum Materials Service, 1991.

Ensminger, M. E. *Poultry Science.* 3rd ed. Danville, IA: Interstate Publishers, Inc., 1992.

Ensminger, M. E., and C. G. Olentine, Jr. *Feeds and Nutrition.* 2nd ed. CA: The Ensminger Publishing Company, 1990.

Largen, Velda L. *Guide to Good Food.* South Holland, IL: Goodheart-Willcox Company, Inc., 1988.

Lesson 3:
Energy's Role in Livestock Nutrition

Two sources of energy are carbohydrates and fats. As in humans, excess energy consumption in livestock results in fat storage in the body (excess body weight). For the producer, the right balance of carbohydrates and fats in a ration can also mean lower production costs.

Basic Functions of Energy

Maintenance of life - Nutrients providing energy are needed for maintenance. Work done by the animal's vital functions is called its basal metabolism. The basal metabolism of an animal is the animal's heat production while it is at rest and not digesting food. Vital life processes, such as the beating of the heart, maintenance of blood pressure, nerve impulse transmission, breathing, and the work of other internal organs depends upon a supply of nutrients.

Energy nutrients are oxidized in the muscles to keep them in a state of tension. An animal requires more energy standing than lying down, and even more energy to move about or do work.

Energy supplies the fuel that maintains the body temperature of the animal. There are several sources of heat to maintain body temperature. These include the work of the vital organs, normal activity of the animal, work done by the animal, and shivering.

Growth and production - It is only after all the maintenance needs of the animal are met that energy nutrients can be used for growth and production. Some energy is also lost through the feces, urine, and gases produced by the body.

Fattening livestock requires a large amount of energy nutrients. Energy is used in the secretion of milk and the production of eggs and wool. The energy not used for other needs becomes fat within the body tissues. Fat deposits in the tissues makes the meat tender, juicy, and gives it a better flavor.

The energy requirements of lactating animals are almost twice as high as for those not producing milk. This energy must also be in the form of net energy. A shortage of energy in the ration will limit milk production, although the animal will use some body fat for milk production if the ration is energy deficient.

Energy is used for the development of the fetus in pregnant animals. It is important that rations during the gestation period have sufficient energy to maintain the animal in a healthy condition without its getting too fat.

When feeding working horses, energy above the needs for maintenance must be provided for work. Several factors affect the amount of energy needed, including the intensity and duration of the work, the condition and training of the horse, the ability and weight of the rider or driver, the horse's degree of fatigue, and environmental conditions under which the horse is performing work.

Carbohydrates and Fats (Lipids)

Carbohydrates and lipids are the major sources of energy in livestock rations. Some energy also comes from protein in the ration. Of these sources, carbohydrates are the most readily available, are easily digested in greatest quantities in most feeds, and are generally lower in cost. Lipids (fats and oils) are the second most important source of energy for livestock. However, during warm weather, it is difficult to store feeds that are high in fat content because they tend to become rancid (bad odor and flavor). This makes the feed unpalatable, and animals are reluctant to eat it. Sometimes, rancid feed may cause digestive disturbances, making the animal sick. Proteins are seldom fed for their energy content because of the higher cost.

Carbohydrates - Carbohydrates make up almost 75 percent of a ration. Carbohydrates are organic compounds that contain three major elements: carbon, hydrogen and oxygen. Growing plants produce carbohydrates by photosynthesis (6 CO_2 + 6 H_2O + energy from the sun = $C_6H_{12}O_6$ [glucose] + 6 O_2). Carbohydrate compounds found in plants include starch, sugars, hemicellulose, cellulose, pectins, gums, and lignins. Most carbohydrates are combinations of sugars. One way carbohydrates are classified is by the number of sugar molecules they contain. For example, monosaccharides contain one sugar molecule.

The simplest carbohydrates are sugars. Sugars are the most easily digested, while cellulose and lignin are more difficult to digest. Sugars provide the energy requirements necessary for various body functions.

Carbohydrates make up about 75 percent of all dry matter in plants. The more easily digested forms of carbohydrates are generally found in the seeds, roots, and tubers of the plants. Most carbohydrates are combinations of saccharides or sugars. One way carbohydrates are classified is by the number of molecules of sugars they contain. For example, monosaccharides contain only one sugar molecule.

The plant's fiber cells contain hemicellulose and cellulose, which are harder to digest. As a result of digestion, some of the hemicellulose and cellulose are converted to glucose. Because digestion of these forms is more difficult, they are less efficient sources of energy for the animal.

Carbohydrates fall into two groups--fiber and nitrogen-free extract (NFE). Fiber contains hemicellulose, cellulose, and lignin. The NFE group includes sugar, starch, some hemicellulose, and the more soluble parts of cellulose.

Starch is made up of many molecules of glucose. Plants store energy as starch in grain. Grains have a high feeding value because the starch digests easily.

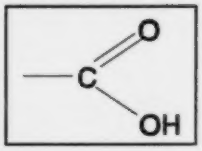
An animal's ability to use fibrous sources of carbohydrates is related to the bacteria in the digestive system. Ruminants, which have a high bacteria population in the rumen, also make use of energy from the ration's fiber portion. Bacterial action breaks down the fiber into volatile fatty acids, which are absorbed through the rumen wall. Roughage in a ruminant's ration can provide much of the maintenance energy needed by the animal. On the other hand, avians and animals with one stomach are less able to use energy from fiber.

To prevent excessive weight gains, increase the level of fiber in the ration for mature breeding animals. Fiber helps keep an animal's waste elimination "regular." Fiber is also an important part of the ration, keeping the monogastric (single-stomached) animal's digestive system regular, and giving the feed bulk.

Lipids (fats and oils) - Chemically, lipids are made up of carbon, hydrogen, and oxygen. There is more carbon and hydrogen and less oxygen in a fat molecule than in a carbohydrate molecule. Therefore, lipids supply approximately 2.25 times as much as energy as an equal weight of carbohydrates.

At body temperature, fats are solids and oils are liquids. In animal nutrition, both are generally called fats.

FIGURE 3.1 - Carboxyl Group



Fat composition - Fats are composed of two units--fatty acids and glycerol. Fatty acids consist of a carbon chain, 2-20 carbons in length, which contains a carboxyl group (COOH). Saturated fatty acids contain carbons attached with all single bonds. Unsaturated fatty acids contain carbons attached by double bonds. These double bond sites are chemically reactive; as a result, they are less stable than saturated. As the number of double bonds increases, the melting point of fat is lowered and the fats become softer (oils).

Glycerol is the second constituent of fat. Fats are formed when one glycerol combines with three fatty acids to form a triglyceride.

Rancidity - Bad odors and flavors may be a problem with both saturated and unsaturated fats. Oxidative rancidity occurs only in unsaturated fats. The presence of oxygen is needed, and rancidity is favored by moist conditions. Rancid foods have a changed flavor, odor, and nutritional value because essential fatty acids are destroyed. Rancidity is part of hyperoxide formation, which promotes aging and destroys the immune system. It can be prevented with antioxidants (Vitamin E) and by storing fats in a cool environment.

Three fatty acids (linoleic, linolenic, and arachidonic acids) are considered dietary essential nutrients since they are not synthesized by nonruminants. However, these fatty acids *are* synthesized by microorganisms in the rumen.

Fat storage - The animal body stores fat as marbling in the muscle tissue or in adipose (fatty) tissue. Adipose tissue contains reserve energy, which an animal could use to help sustain life if feed supplies were cut off.

Fats can raise the energy level of the diet and/or the flavor, texture, and palatability of the feed. Added fat will reduce the dustiness of the feed. Show animals are sometimes fed rations high in fat to improve the glossiness of the hair coat.

Rations for adult animals should contain no more than 3-5 percent fat for ruminants and 15-20 percent fat for non-ruminants. Because fats carry fat-soluble vitamins, some fat in the ration is desirable. Too much fat in the diet will reduce feed intake and increase the chances of scouring (diarrhea).

Absorption of Carbohydrates and Lipids

Carbohydrates - Most carbohydrate absorption occurs in the small intestine; a small amount is absorbed in the large intestine. Starches and sugars are converted to glucose, fructose, and galactose. Crude fiber converted to short, chained fatty acids or glucose by digestion. By osmosis, nutrients pass into the blood capillaries through semipermeable membranes of the digestive tract, then through the liver and into the bloodstream for circulation throughout the body.

Lipids - The digestion process separates fatty acid from the glycerol molecule. Fatty acid is absorbed into lacteals (lymphatic vessels) and then into the bloodstream, where it moves to various parts of the body and is recombined with glycerol to form fat.

Sources of Energy for Animals

Primary sources of energy nutrients are grain and grain by-products. Feeds are energy concentrates when their crude protein content is less than 18 percent.

Shelled corn - The highest energy feed available for livestock rations is shelled corn. It is the most widely grown and used feed grain crop. Corn produces more pounds of total digestible nutrients (TDN) per acre than any other feed grain. It is an economical and superior source of energy for livestock.

Oats - Oats have about 85 percent of the energy of shelled corn. They are higher in crude protein than shelled corn and add fiber and bulk to the ration. When fed to ruminants, oats help to maintain the rumen function. Oats are not a good fattening feed, but they are used extensively for horses, young growing stock, show stock, and breeding animals. Oats are generally rolled, crimped or ground for feeding.

Barley - Barley is almost equal to corn in energy value, but it lies between corn and oats in fiber content. It is used in the ration similarly to oats. Barley can replace up to 50 percent of corn in fattening animal rations. To improve taste, barley is usually steam rolled, crimped or coarsely ground. Barley is sometimes cooked to improve its taste when used for beef show animals.

Grain sorghum - There are many varieties of grain sorghum, including milo, kafir, and various hybrids. Most grain sorghum is grown in the western part of the U.S. in semi-arid regions where corn does not grow well. Grain sorghum is similar to shelled corn in composition and can replace up to 100 percent of the corn in a feedlot ration. It is usually rolled or crimped when included in livestock rations.

Forages (roughages) can supply some energy needs in the livestock ration, although they are not as concentrated an energy source as grains. The value of forages for livestock feed is highly dependent on the time of harvesting. As forage plants mature, the crude fiber content increases, which lowers the digestibility of the feed.

Corn silage - Corn silage, which contains almost 50 percent grain, is an excellent energy source for certain classes of livestock, such as cattle.

Hay - Good quality hay, especially legumes, can provide almost all of the energy needs of a ruminant animal. The quality is greatly dependent upon the time of harvesting.

Pastures - Properly managed pastures can be a good source of nutrients for livestock. Rotate and fertilize pastures to get the best yield and nutritional value.

Fat - Feed-grade animal fat is a byproduct of packing, poultry processing, and animal rendering plants. Animal fat is an economical source of energy used in the manufacturing of commercial mixed feeds. Commercial feed mixes contain 1-7 percent animal fat, depending on the type of feed. Animal fat in the feed reduces the dustiness of the feed, improves its color, texture and palatability, reduces wear on feed mixing equipment, and improves pelleting characteristics.

Deficiency and Toxicity Symptoms

Deficiency - Too little energy in the ration causes several problems for all classes of livestock. Typical of these are:

1. Slower growth in the young
2. Delay in the onset of puberty
3. Decrease in milk yield in lactating females
4. Shortened lactation period
5. Loss in body weight
6. Several kinds of reproductive problems, including reduced fertility and delayed estrus
7. In sheep, a reduction in wool quantity and quality
8. Higher mortality rate
9. Lowered resistance to disease and parasites
10. Weakness, generally poor condition, and an unthrifty appearance
11. Loss of subcutaneous fat
12. Reduction in levels of blood glucose, calcium, and sodium.

Toxic effects - Feeding too much energy results in ketosis or obesity. Animals that are too fat can be less fertile, conceive less, and have delayed estrus.

Ketosis occurs when an animal has a higher energy demand (such as lactating dairy cattle) and a low supply of carbohydrates. To meet the energy demand, the animal increases the metabolism of fats. The increased fat metabolism rate overloads the liver with ketone acids. Ketone acids can provide energy for muscles but **cannot** provide energy for the brain. If the situation is not corrected, glucose blood levels drop so low that the animal collapses, goes into a coma, and dies. This often happens to the best milk cows because of high energy requirements.

Summary

Fuel is supplied to the body by energy nutrients. The major sources of energy in livestock rations are carbohydrates and fats. Energy is used for digestion; absorption of nutrients; breathing; heart action; movement of muscles; production of milk, eggs, wool, and mohair; waste formation and excretion; and to supply heat to maintain body temperature. Some feed energy is lost through the feces, urine, and gases produced in the body. Excess energy not used to sustain life is stored as body fat.

Credits

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Gillespie, James R. *Animal Nutrition and Feeding.* Albany, NY: Delmar Publishers, Incorporated, 1987.

Largen, Velda L. *Guide to Good Food.* South Holland, IL: Goodheart-Willcox Company, Inc., 1988.

Lesson 4:
Protein's Role in Animal Nutrition

Every nutrient plays an important role in animal nutrition. Protein plays an integral part in several body functions in animals and humans. Protein deficiencies in humans appear as stunted growth, discolored skin, and body sores. Protein deficiencies are rare in humans because there is a great emphasis on proper diets. But there is an increasing problem with excess amounts of proteins in human diets. Unused, excess protein in a diet turns into body fat. Research has shown excess body fat leads to many health problems in humans. Good sources of protein for humans are poultry, fish, dairy products, and dried peas and beans.

Functions of Protein

Protein plays similar roles in livestock nutrition as it does in human nutrition. The word "protein" originates from the Greeks. It means "of primary importance." Proteins are the lumberyards that supply the materials necessary for building and maintaining the body. Proteins consist of carbon, hydrogen, nitrogen, and oxygen compounds.

Uses of protein include building, repairing, and maintaining body parts such as muscles, skin, body tissues, hair or feathers, and hooves. Protein also produces body regulators, such as enzymes and hormones. These body regulators aid in the reproduction, digestion, and health maintenance of an animal.

Protein is a good source in the production of blood glucose, which is an important function of proteins. Proteins can be modified for use in genetic compounds, such as DNA, RNA, and ATP. Proteins can also be used as energy when excess amounts are fed, but they are *only* used as energy after the body's needs are met. Proteins also function as precursors to some B-complex vitamins.

Loss of weight, rough hair coats, poor appetites, low digestive efficiencies, and lower reproduction rates are symptoms of animal protein deficiencies. If these deficiencies are not corrected, an animal may die and the investment will be lost. Death usually occurs because of a lack of amino acids, which are produced by proteins. Functions of protein and deficiency symptoms apply to each class of livestock.

The Role of Amino Acids in Protein Synthesis

During digestion, amino acids synthesize food proteins to be used for a specific physiological function. Genetic compounds, such as DNA and RNA, determine which proteins are needed by the body. This information is sent to the amino acids, which synthesize the proper protein for the situation. These proteins can be used for skin, hair, hoof, or muscle development. Amino acids are nitrogen compounds that originate from proteins fed to the animal. A good description of amino acids is "the bricks and mortar of which muscles, body tissues, skin, and hair are built."

Amino acids are separated into two groups: essential and nonessential. Essential amino acids must be provided in non-ruminant diets. Nonessential amino acids can usually be synthesized by the animal. There are 23 amino acids--10 essential ones and 13 nonessential ones. All classes of livestock require both essential and nonessential amino acids.

Classes of livestock synthesize amino acids differently. Ruminants can synthesize their own amino acids as long as enough nitrogen and protein are fed in the diet. Non-ruminants can produce some nonessential amino acids, but they cannot produce any essential amino acids. These must be provided in their diet. DNA serves as the information center that links amino acids together to form a specific protein. The role of amino acids is to link together to form a specific protein for a particular physiological function.

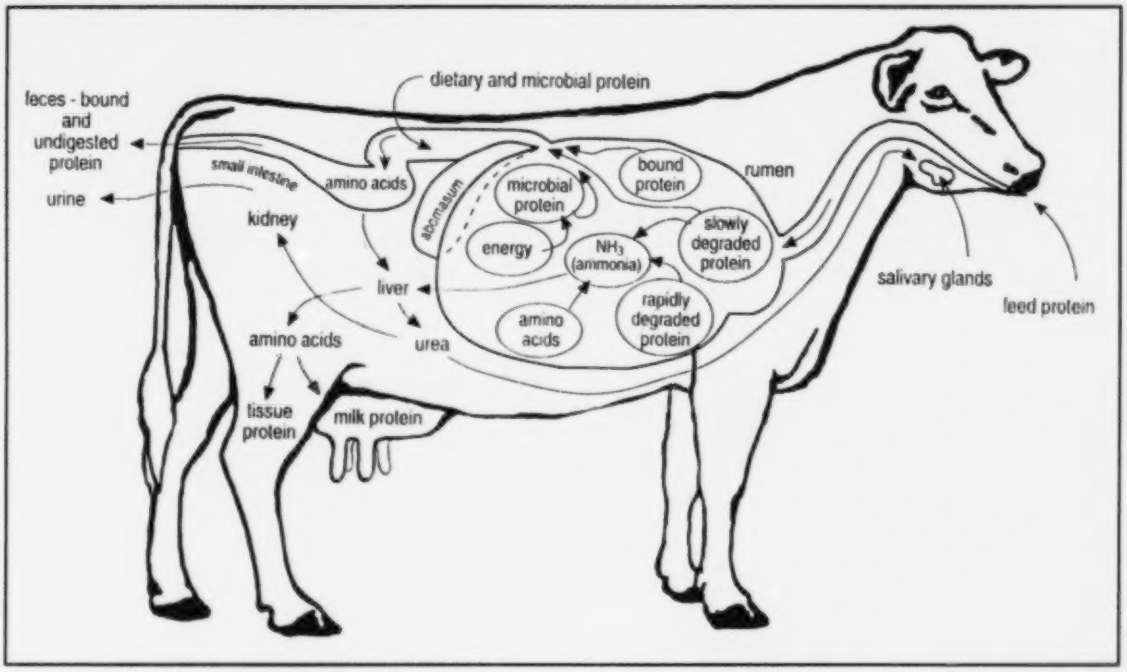
Essential Amino Acids

The 10 essential amino acids are:

- Phenylalanine
- Valine
- Threonine
- Tryptophan
- Isoleucine
- Methionine
- Histidine
- Arginine
- Lysine
- Leucine

There are 13 nonessential amino acids, as well.

FIGURE 4.1 - Protein Utilization in the Ruminant


dietary and microbial protein
feces - bound and undigested protein
urine
small intestine
amino acids
abomasum
microbial protein
bound protein
rumen
kidney
slowly degraded protein
energy
NH_3 (ammonia)
liver
salivary glands
feed protein
rapidly degraded protein
amino acids
urea
amino acids
tissue protein
milk protein

Symptoms of Protein Deficiency

Symptoms of amino acid/protein deficiency are lack of growth, poor hair coat, lack of muscling, and lack of energy. Dietary proteins are necessary for amino acids, and amino acids are needed for making specific proteins for usage by the body. If a food is lacking in an essential amino acid and the animal cannot synthesize it, the amino acid must be supplied in the diet. For example, corn is deficient in lysine, which is an essential amino acid. Therefore, for certain proteins to be synthesized, lysine must be supplied from another feedstuff.

Sources of Protein

Strong sources of protein are very important as livestock feed. Protein sources are divided into three groups: animal, plant, and synthetic. Rations are figured by the percentage of crude protein (CP) supplied by a source. Therefore, all sources of protein are listed by percentage of crude protein. Following are some good sources of plant and animal protein sources. (Note: These are book value ranges. Home-raised protein sources should be tested for CP values.)

Animal protein sources
Feather meal, 87 percent CP
Blood meal, 80 percent CP
Fish meal, 60 percent CP
Poultry by-product meal, 55 percent CP
Meat scrap, 55 percent CP
Meat and bone meal, 50 percent CP
Dried skim milk, 34 percent CP
Dried whole milk, 25 percent CP

Plant protein sources
Sunflower meal, 47 percent CP
Soybean meal, 44 percent CP
Cottonseed meal, 41 percent CP
Rapeseed meal, 37 percent CP
Dehydrated alfalfa meal, 18 percent CP
Alfalfa hay, 15 percent CP
Red clover hay, 13 percent CP
Wheat grain, 12 percent CP
Oat grain, 12 percent CP
Corn grain, 9 percent CP

Synthetic protein sources - The most commonly used synthetic protein is urea. Urea can only be fed to ruminants because microbes present in these animals feed on the urea. It should be fed only to ruminants on high energy diets, such as fat cattle on the dry lot. Urea consists of 45 percent nitrogen and is a good source for amino acids. Toxicity (poisoning) can occur if excess amounts are fed to ruminants. If the microbes cannot digest all of the urea, an ammonia byproduct is produced, which is damaging to the urinary tract.

Determining Which Proteins Should be Used

Ruminants - The first step in deciding which proteins to feed ruminants is to determine which proteins will feed the microorganisms or "bugs" in the rumen. These **microbes** can synthesize amino acids from nonprotein nitrogen that non-ruminants cannot.

A producer can choose true proteins, such as soybean meal or cottonseed meal. The other option is to feed a nonprotein nitrogen (NPN) feedstuff, such as urea or anhydrous ammonia. These two types of proteins supply nitrogen used by the microbes for protein synthesis.

When using true proteins such as plant protein or animal protein, crude protein does not determine digestibility (amount of protein available to the animal). Crude protein is the total amount of protein available in the feedstuff, but an animal cannot digest all the protein available. Digestible protein best describes the amount of protein used by the animal. Price, of course, is another influencing factor.

The next consideration is the **amount** of protein digested by the rumen. Most nonprotein nitrogen feedstuffs are digested and utilized by microbes in the rumen.

In Figure 4.1, nonprotein feedstuffs are considered rapidly degraded proteins. Excess amounts of nonprotein nitrogen can result in higher levels of ammonia in the rumen. Excess rumen ammonia is absorbed into the bloodstream and converted to urea in the liver. The nonprotein nitrogen (rapidly degraded protein) is converted into NH_3 (ammonia), and the excess enters the bloodstream, is transformed into urea in the liver, and leaves the body through the urine. Excess nonprotein nitrogen can result in ammonia toxicity due to high levels of blood ammonia. Only limited amounts of NPN can be used. (Four pounds of urea per cow per day is a safe maximum.)

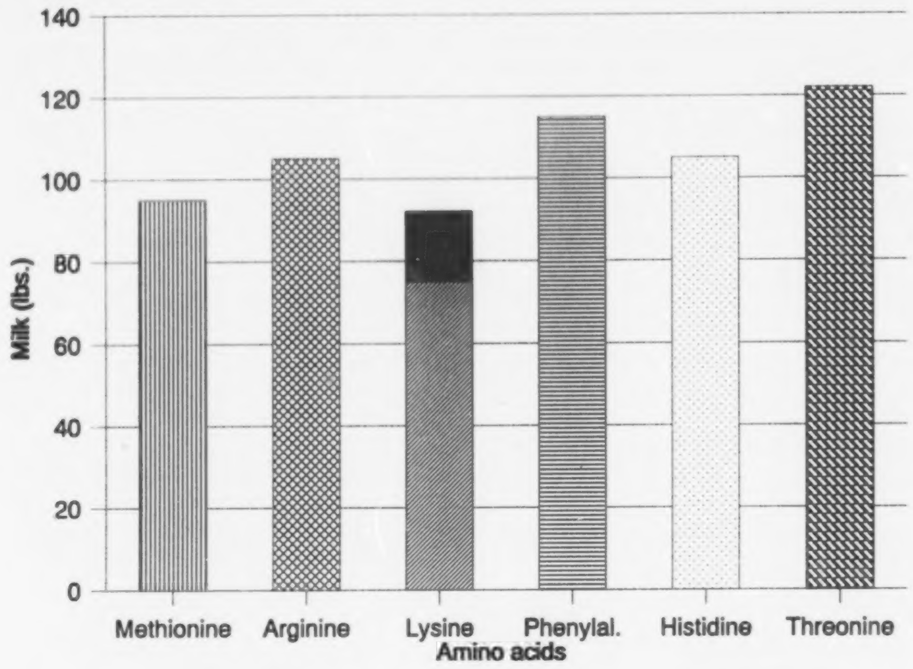
In Figure 4.1, bound proteins are the undigestible portions of true proteins. These proteins cannot be digested by the rumen or the small intestine. These proteins are the difference between crude protein and digestible protein. Bound proteins

TABLE 4.1 - Digestibility in Swine Feedstuffs

Source	*Crude Protein*		*Isoleucine*		*Leucine*		*Lysine*		*Meth. & Cystine*		*Threonine*		*Tryptophan*	
	Tot.%	Total Dig.%	Tot.%	Total Dig.%	Tot.%	Total Dig.%	Tot.%	Total Dig.%	Tot.%	Total Dig.%	Tot.%	Total Dig.%	Tot.%	Total Dig.%
Blood meal	86	78	1.13	.75	11	9.24	7.85	6.51	1.91	1.45	3.57	2.9	1.08	.85
Meat and bone	61	44	1.66	1.11	3.7	2.63	3.1	2.29	1.9	1.33	1.86	1.2	.37	.23
Soybean meal	47.6	38.5	2.2	1.83	3.66	3.07	3.01	2.55	1.3	1.05	1.88	1.48	.57	.46
Raw soybeans	38	21	1.7	.88	3	1.56	2.5	1.52	1.2	1.0	1.6	.9	.46	.26
Heated soybeans	39	28	1.8	1.3	3.2	2.37	2.5	1.97	1.1	.83	1.6	1.15	.54	.38
Feather meal	83	59	3.69	2.9	6.63	5.1	1.59	.81	4.24	3.0	3.49	2.58	.42	.25
Corn	8	6	.32	.25	1.11	.95	.27	.18	.37	.11	.32	.07	.08	.004
100 lb. pig needs per day (4.1 lbs. feed total)	16			.019		.025		.031		.017		.02		.005

Source: "Apparent Ileal Digestibility of Crude Protein and Essential Amino Acids in Feedstuffs for Swine - 1992." Chicago, IL: Heartland Lysine, Inc., 1992.

FIGURE 4.2 - Effects of Amino Acids on Milk Production



enter and leave the body virtually undigested. There are also true proteins that are considered rapidly degraded proteins. A large part of these proteins are used by microbes in the rumen.

The last form of protein is slowly degraded protein. Part of these true proteins are digested in the rumen. Microbes in the rumen use some of them, and the remaining portions escape into the small intestine, where it is digested along with microbial protein and then used for muscle formation and milk production.

The last step in classifying feedstuffs is based on **rumen digestion.**

1. Soluble proteins disappear or are digested in two hours or less after entering the rumen. These proteins are classified as "rapidly degraded protein" in Figure 4.1. Example sources are urea, alfalfa silage, and anhydrous ammonia. Most of these proteins are used by microbial cells ("bugs").

2. Degradable proteins are broken down at a measurable rate over time. The amount of protein digested in the rumen depends on the rate and amount of time spent there. These proteins are classified as "rapidly and slowly degraded proteins" in Figure 4.1. These proteins are used by microbial cells and the small intestine. Examples are soybean meal and cottonseed meal.

3. Escape or bypass proteins bypass rumen digestion. Most of them are digested and absorbed in the small intestine. These proteins are classified as "slowly degraded proteins" in Figure 4.1. Examples are fish meal, blood meal, meat and bone meal, and corn gluten meal.

4. Nonprotein feedstuffs cannot supply all the protein necessary in the diet, but true proteins can. Nonprotein feedstuffs must be supplemented with true proteins.

FIGURE 4.3 - Balancing a Ration

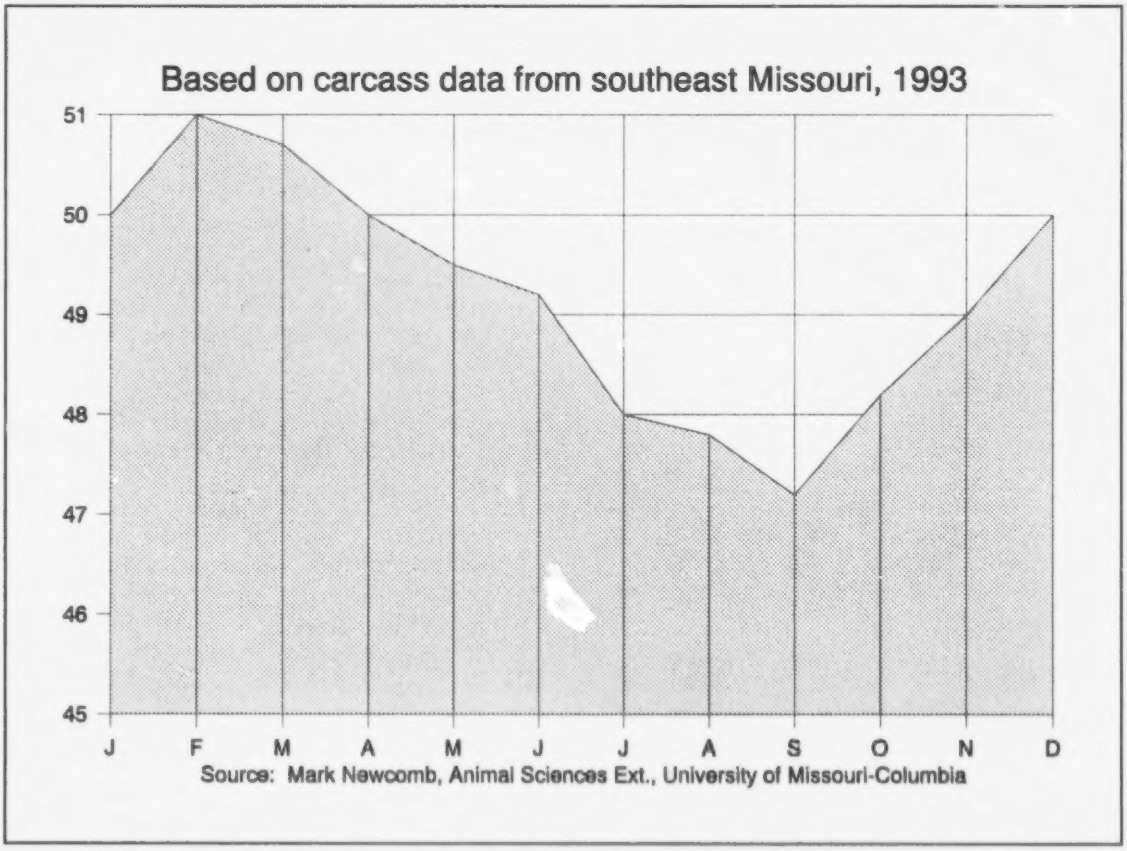
Corn **8**		**32**	80% x 4.1 = 3.28 lbs. of corn
	16	**8**	20% x 4.1 = .82 lb. of soybean meal
Soybean meal **48**		**40**	

5. Figure 4.2 shows the effects of amino acids on milk production. Milk production in dairy cattle is limited by the lowest limiting amino acid (here, lysine). In Figure 4.2, this animal would only produce 75 lbs. of milk daily because the lysine becomes limiting at this level of milk production.

   Figure 4.2 also shows what would happen if the diet was supplemented with a bypass protein high in lysine. When this occurs, lysine is no longer the limiting amino acid; methionine now becomes the limiting amino acid. This change results in increased milk production (75 lbs. to 92 lbs. daily). Paying close attention to ration balancing can mean a much more profitable operation. This concept of limiting amino acids also applies to nonruminants.

Nonruminants - Protein digestibility is easier to understand in nonruminants because there are no microbial cells to feed and no predigestion before entering the stomach. Table 4.1 shows the requirements for a growing 100 lb. market hog, as well as the crude protein, digestible protein, and amount of amino acids present in different feedstuffs. A 100 lb. market hog requires a 16 percent crude protein diet. The average 100 lb. hog consumes 4.1 lbs. of feed daily. Of that, 16 percent needs to be crude

FIGURE 4.4 - Swine Percentage Lean Over Time



Source: Mark Newcomb, Animal Sciences Ext., University of Missouri-Columbia protein, which is .66 lb. of crude protein. (Remember, this is an estimate.)

To further understand the hog's requirement, look at the bottom line of Table 4.1. It shows that the amino acid requirement for the 100 lb. hog is .019 lb. of isoleucine, .025 lb. of leucine, .031 lb. of lysine, .017 lb. of methionine and cystine, .02 lb. of threonine, and .005 lb. of tryptophan.

Blood meal, for example, has a crude protein percentage of 86 percent, of which 70 percent can be digested. Of 100 lbs. of blood meal, 86 lbs. are crude protein, while 70 lbs. are usable (digestible) protein. Of the 100 lbs. of blood meal, the total amount of isoleucine is 1.13 lbs. There is .75 lb. of usable (digestible) isoleucine available in 100 lbs. of blood meal. To find out the digestible amount of isoleucine available in 50 lbs. of blood meal, multiply 50 lbs. of blood meal by .0075 digestible isoleucine. (50 x .0075 = .375 lb. of digestible isoleucine)

To find the available digestible leucine in 50 lbs. of blood meal, multiply 50 lbs. of blood meal by .0924. (50 x .0924 = 4.62 lbs.) Let's use this information in a real-life ration. On the average, a 100 lb. hog eats 4.1 lbs. a day. To find out if the ration below meets the amino acid requirements of this hog, find out the total amount of each feedstuff.

In the following ration, 3.28 lbs. of the 4.1 lbs. eaten is corn, and .82 lb. is soybean meal. Usually, lysine is the limiting amino acid in most hog rations. Soybean meal will supply .021 lb. of lysine (.82 lb. x .0255 = .021). The corn supplies .006 lb. of lysine (3.28 x .0018 = .006). The hog requires .031 lb. of lysine; these feedstuffs supply .027 lb. of lysine (.021 + .006). This ration, therefore, is lacking lysine. Remember that all hog rations need vitamins and minerals, which have not been figured in yet. In real life, this ration would be balanced for lysine (not protein) to prevent this deficiency from occurring. (See Figure 4.3.)

Remember that the 4.1 lbs. eaten daily is an average. In the winter, hogs will eat more than in the summer. To the average producer, using the above ration in the winter wastes money because it includes more amino acids than the hog needs. In the summer, the hog's appetite decreases and its needs are not met because it eats less than 4.1 lbs. a day. Figure 4.4 shows this difference in eating habits.

If using the above ration, packers receive leaner hogs in the winter because hogs are eating more, so their amino acid needs are met, resulting in more muscle. In the summer, when hogs eat less, their amino acid needs are not met and fat is produced instead of muscle.

The processing of feedstuffs improves protein digestibility. Compare raw soybeans to heated soybeans on Table 4.1. Crude protein remains about the same, but the digestibility of heated soybeans jumps up 7 percent. This concept also applies to digestibility of amino acids. (See Table 4.1.)

Summary

Understanding protein's role in nutrition is economically important because protein is one of the more expensive components in ration development.

Credits

"Apparent Illegal Digestibility of Crude Protein and Essential Amino Acids in Feedstuffs for Swine - 1992." Chicago, IL: Heartland Lysine, Inc., 1992.

Livestock Nutrition and Feeding (Student Manual). 2nd ed. Columbus, OH: Ohio Agricultural Education Curriculum Materials Service, 1991.

Cullison, Arthur Edison. *Feeds and Feeding.* 4th ed. Reston, VA: Reston Publishing Co., 1987.

Ensminger, M. E., and Olentine, C. G., Jr. *Feeds and Nutrition.* 2nd ed. Clovis, CA: The Ensminger Publishing Company, 1990.

Largen, Velda L. *Guide to Good Food.* South Holland, IL: Goodheart-Willcox Company, Inc., 1988.

Lesson 5:
Minerals' Role in Animal Nutrition

General Functions of Required Minerals

When an organic material such as feed is burned, the leftover ash is the material's mineral content. Minerals are inorganic substances needed by animals for production and maintenance; they are needed in very small amounts in the ration. If a particular mineral is needed, it must be provided in the diet in a form that can be digested, absorbed, and used in metabolism. Rations must be formulated so that a mineral imbalance does not occur.

At least 19 mineral elements are needed by various animal species. These minerals are divided into two groups based on the quantities needed. Those needed in larger amounts are called macro-minerals, and those needed in small amounts are called trace or micro-minerals.

Macro-minerals include calcium (Ca), sodium (Na), phosphorus (P), magnesium (Mg), potassium (K), and chlorine (Cl). Trace or micro-minerals needed include sulfur (S), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), and zinc (Zn).

Although the mineral content of an animal's body is small (2-5 percent, depending on the species), minerals perform many essential functions. Minerals provide material for the growth of bones, teeth, and soft tissues. Minerals fill in soft bone and teeth cells to make the cells hard and rigid. Minerals regulate many vital chemical processes. They also aid in muscular stimulation and activity, reproduction, digestion of feed, repair of body tissue, formation of new tissue, and release of body heat for energy.

Minerals are an essential part of the blood, body fluids, and some secretions in the body. They help regulate the acid-base balance to maintain body fluids at a pH of about 7.0. Other functions of minerals include cell structure and integrity; part of organic compounds such as proteins, amino acids, carbohydrates, and fats; control the location of body water through osmotic pressure; coenzymes that activate enzymes; necessary components of hormones; and egg production.

Toxic minerals - Some minerals, such as arsenic, cadmium, mercury, and lead, are toxic to animals. Selenium helps protect against arsenic, cadmium, and mercury poisoning.

Arsenic is found in some herbicides, insecticides, and defoliants. Crops do not grow well on soils contaminated with arsenic. Crops recently sprayed with a material containing arsenic can cause arsenic poisoning if livestock graze on the foliage.

Cadmium is normally not found in soils in excessive amounts; however, contamination from industrial plants or sewage from cities causes a buildup of cadmium in the soil.

Mercury can be discharged into air and water by industrial plants, and is used in herbicides and fungicides for seed treatment.

The major danger from lead is contamination of plants from lead in the air. The most common source of lead toxicity is lead-based paint from discarded paint cans or peeling buildings.

Macro-Minerals: Functions, Deficiencies, Interactions, Sources

Calcium (Ca)
Major functions - An animal's bones and teeth contain 99 percent of the calcium found in its body. Calcium is also an important part of milk and eggs, so it is essential in the diets of lactating animals and laying hens. Calcium is also important for proper nerve and muscle functioning, for maintaining the acid-base balance of the body fluids, and for blood coagulation.

Deficiencies - A deficiency of calcium will result in abnormal bone growth and weak bones in all classes of livestock. Young animals that are deficient in calcium can develop rickets, where the normal amount of calcium is not deposited in the growing bones. The joints then become enlarged and bones become weak, soft, deformed, and fragile. The calcium in the spongy part of the bones is withdrawn first to meet the needs of the animal. If the deficiency continues, the calcium is withdrawn from the shafts and other structural parts of the bone. Bones then become porous, weak, and fragile. Older animals with a calcium deficiency can develop osteoporosis.

Calcium-deficient poultry have thin-shelled eggs, reduced egg production, and lowered hatchability. Milk fever can occur when cattle are deficient in calcium shortly before or after calving.

Interrelationships - The ratio of calcium to phosphorus, magnesium, and zinc must be correct for the proper utilization of these minerals. The calcium-to-phosphorus (Ca:P) ratio should be 1:1 to 2:1. Excessive calcium in the ratio will result in poor utilization of these other minerals. An excess of magnesium decreases the absorption of calcium, replaces calcium in the bone with magnesium, and causes an increase in the excretion of calcium from the body. The vitamin D level is critical because a deficiency of vitamin D in the ration prevents the proper utilization of calcium. Also, an excess amount of calcium reduces the absorption and utilization of zinc.

Sources - Legume forages and animal-origin protein supplements are the highest in calcium content, ranging from one to two percent on a dry weight basis. Plants grown on well-fertilized soils are higher in calcium content than those grown on poorer soils. Other good feed sources of calcium include milk, bonemeal, and citrus pulp. Rations that are high in grain need more calcium supplements, while legume forage rations need little or no added calcium.

Calcium supplements come from various materials. Typical sources are ground limestone, oyster shell flour, and marble dust. Supplements can be fed free choice in a mineral mix or added to the ration at the proper level.

Grains, straw, dried mature grasses, and protein supplements from plant sources contain the least amount of calcium, ranging from 0.01 to 0.15 percent. Grass forages generally contain 0.35-0.75 percent calcium. In the end, only about 20-30 percent of calcium in the average ration is absorbed from the intestinal tract and taken into the bloodstream.

Salt (NaCl)

Major functions - Salt contains the mineral elements sodium (Na) and chlorine (Cl), which are needed by all classes of livestock. Cattle, sheep, and horses usually require more salt supplements than swine or poultry because of the higher levels of forages in their diets. Most grains and forages produced on nonirrigated soils are low in sodium and chlorine content. Sodium and chlorine are important for maintaining osmotic pressure in the body cells. The assimilation of nutrients and removal of waste from cells depend on maintenance of the proper osmotic pressure. Sodium is the major mineral responsible for maintaining a neutral pH level in the body tissues. Chlorine is essential for the formation of bile and hydrochloric acid in the digestive juices. Both sodium and chlorine affect muscle and nerve activity.

The requirements for salt in the diet vary with the specie, type of feed fed, activity of the animal, air temperature, water salinity, and production. Milk is especially rich in salt; therefore, lactating animals have a higher salt requirement. Heavy sweating causes a rapid loss of salt from the body, increasing the animal's salt requirement.

Deficiencies - Animals that are temporarily deprived of salt can develop an abnormal appetite for dirt, manure or urine. Symptoms of salt deficiency are slow to develop because the salt in the body is recycled when the intake is low. However, some symptoms which may occur include reduced growth and efficiency of feed utilization in growing animals, and lowered reproduction, reduced milk production, and weight loss in adult animals. In laying hens, lowered production, loss of weight, and cannibalism may result from a salt deficiency.

Ration requirements - Salt can be mixed in the ration at 0.25-0.50 percent of the ration and/or fed free choice. During the lactation period of cattle, sheep, and horses, include salt at about one percent of the ration. Generally, include about 0.50 percent salt in a ration for swine. Including salt in the ration helps to ensure that all animals get an adequate amount; it also improves palatability.

Sources - Supplemental salt can be added in block form, as loose salt or in the mineral mix.

The price and availability of the various sources are the main considerations when deciding which to use. In a ration, it is a common practice to add salt (0.25-0.50 percent) as the carrier for trace minerals because of the improved palatability of the mix. Salt fed to cattle on pasture often has organic iodine added to prevent foot rot and magnesium oxide added to help prevent grass tetany. Block salt is easy to use, does not need protection from wet weather and stimulates salivation. There is little danger of the animal overeating salt. However, some animals might not get enough salt or might develop sore tongues if available only in the block form.

Loose salt can be plain or have trace minerals added. It is easy for the animal to consume but needs protection from rain or snow. Another disadvantage is that animals starved for salt might eat too much of the loose form. When salt is fed loose, make sure there is an adequate water supply to prevent toxic reactions from overeating. Salt fed loose should be protected by a mineral feeder.

Toxicity - Toxicity rarely develops from the consumption of salt, unless ruminants that overeat salt are restricted in their access to water. As much as 15 percent of the ration can be given to cattle on pasture to limit grain intake, with no toxicity resulting. However, salt toxicity can readily occur in nonruminants. It is characterized by a staggering gait, blindness, and other nervous disorders. Also, ruminant animals that have been salt starved can overeat if given unlimited access to salt, and overeating can cause digestive upset or death.

Phosphorus (P)

Major functions - Phosphorus is a vital element in many body functions, and is helps interrelationships with several other macro- and trace minerals. Approximately 80 percent of phosphorus in the body is found in the bones and teeth; therefore, it is a key element in their proper growth and development. Phosphorus is a component of phospholipids, which are important in lipid transport and metabolism, as well as cell-membrane structure. Phosphorus affects appetite, milk and egg production, energy metabolism, conversion of carotene into vitamin A, and utilization of vitamin D. Phosphorus is a component of RNA and DNA and is involved in other metabolic processes as a constituent of several enzyme systems.

Deficiencies - A deficiency can result in rickets or osteoporosis, as well as in poor appetite, slow gains, lower milk and egg production, reproductive problems, poor utilization of vitamin D, deficiency of vitamin A, and generally unthrifty appearance. While it is not a specific symptom of phosphorus deficiency, the deliberate eating of soil and chewing on other nonfeed objects can suggest a phosphorus deficiency in the diet.

Interrelationships - Excessive amounts of calcium and magnesium in the diet reduce phosphorus absorption. In ruminants, an excess of phosphorus can cause urinary calculi, lameness, spontaneous fracture of long bones, and a laxative effect. Phosphorus is more efficiently absorbed than calcium; about 70 percent of ingested phosphorus is absorbed. The Ca:P ratio in the diet should be 1:1 to 2:1.

Sources - Feeds that are good sources of phosphorus include wheat bran, cottonseed meal, and dried skim milk. Legume and grass pastures grown on fertile soils are fairly good sources, while mature, weathered grass forage is generally low in phosphorus. Cereal grains and grain products are fairly high in phosphorus, but much of it is not readily available to nonruminants. An adequate vitamin D level in the diet improves the assimilation of phosphorus. Ruminants are better served by plant sources of phosphorus, while poultry and swine need phosphorus from inorganic sources. Phosphorus supplements can be included in a mineral mix fed free choice and/or added to the ration at the proper level.

Magnesium (Mg)

Major functions - Magnesium helps activate several enzyme systems, relaxes nerve impulses, and is involved in protein digestion. It also serves as a ruminant alkalizer and buffer. Magnesium is a constituent of bones and teeth and is necessary for normal skeletal development. While magnesium is essential for life, it is present in only small amounts in the body.

Deficiencies - A low level of magnesium in the ration can cause decreased utilization of phosphorus and may cause hyperirritability in animals. Magnesium deficiency can cause vasodilation (dilation and relaxation of the blood vessels) which is evidenced by the flushing of the skin.

An acute magnesium deficiency can result in grass tetany. Older, lactating animals are generally affected, but younger animals can develop grass tetany, as well. Grass tetany is likely to develop when levels of magnesium drop below 0.001 percent in the blood serum. Tetany is more likely to develop in cattle and sheep grazing on grass pastures, small grains, highly fertilized fescue in late winter or early spring or grass hay diets. The affected animals become nervous, stagger, and then fall down. Other characteristics of grass tetany include loss of appetite and convulsions. Unless they are quickly treated by an injection of magnesium, they often die.

Interrelationships - Adding magnesium to the ration can cause a zinc deficiency if the ration is not properly supplemented with zinc. Too much magnesium in the ration can interfere with the metabolism of phosphorus and calcium.

Sources - If the diet is low in magnesium, the animal will draw upon the magnesium reserve in its bones. While most rations contain enough magnesium, it might be necessary to supplement the ration, especially under conditions described above that can result in grass tetany. A little more than one ounce of magnesium per head per day for cattle is enough, with a proportionately smaller amount for sheep. Magnesium sulphate or magnesium oxide can be mixed with salt, supplement or fed free choice in areas where grass tetany is a risk.

Potassium (K)

Major functions - Potassium is a major cation (positively charged ion) which affects the osmotic pressure and acid-base balance of the body fluids. It is also involved in controlling muscle activity and the metabolism of carbohydrates and protein synthesis. Potassium is also related to the relaxation of the heart muscle and the secretion of insulin.

Deficiencies - Potassium deficiency may result in reduced growth, general muscle weakness, diarrhea, and an unsteady gait. It may also cause the enlargement of the heart and kidneys, followed by death. Potassium deficiency most often occurs in dry lot finishing cattle or sheep on a high-concentrate ration.

Interrelationships/toxicities - Too much potassium in the diet can result in poor assimilation of calcium and magnesium. The resulting magnesium deficiency leads to poor retention of potassium, and a potassium deficiency results. A high potassium intake causes increased urine output as the animal tries to excrete the excess amount. A toxic level of potassium results in diarrhea, tremors, and heart failure. Excessive salt intake depletes the body's potassium.

Sources - While potassium is essential for life, it is usually adequate most animal rations. Forages are especially high in potassium, containing 3-4 percent on a dry weight basis in the early growth stage. Grains and concentrates contain 0.3-0.7 percent potassium. Animals generally need less than one percent potassium in the ration on a dry weight basis.

Micro-Minerals: Functions, Deficiencies, Interactions, Sources

Sulphur (S)

Major functions - Sulphur is an essential part of the amino acids cystine and methionine and is important in the metabolism of lipids, carbohydrates, and energy. It is also a component of hair, wool, and feathers.

Deficiencies - A deficiency of sulphur in the ration will appear as a protein deficiency. Slow growth and a general unthrifty condition are symptoms of a possible sulphur deficiency. Sheep that are fed nonprotein nitrogen without sulfur supplements show reduced wool growth. (Wool contains about four percent sulfur.)

Ration requirements - Ruminant rations that are high in nonprotein nitrogen (NPN) can be sulphur deficient. A nitrogen-to-sulphur ratio of 15:1 is more desirable as this improves the utilization of NPN in the ration. Nonruminants should be provided sulfur-containing proteins, as well.

Sources - Forages, especially legumes which are harvested in the earlier growth stages, should contain enough sulphur for ruminants. For forages harvested in more mature stages, sulphur supplements might be needed to improve nitrogen utilization. Water supplies in some areas have a high sulphur content. This should be checked to learn the amount of sulphur being included in the diet through the drinking water.

Chromium (Cr)
Major functions - Chromium is believed to be related to glucose metabolism. It is also an activator of certain enzymes and a stabilizer of nucleic acids. Chromium is necessary for the stimulation of the synthesis of fatty acids and cholesterol in the liver.

Deficiencies - A deficiency of chromium is shown by impaired glucose tolerance and a disturbance of lipid and protein metabolism. Supplementation is not generally needed for chromium because such small amounts are required.

Cobalt (Co)
Major functions - Cobalt is used by rumen and cecal bacteria in the growth of rumen bacteria and is essential in the synthesis of vitamin B_{12}.

Deficiencies/toxicities - Cobalt deficiency symptoms are similar to vitamin B_{12} deficiency symptoms. These include poor appetite and general malnutrition, weakness, slow growth, decreased fertility, lower milk and wool production, emaciation, anemia, and eventually death. Toxicity is not likely.

Sources - Good sources of cobalt are usually commercial minerals, poultry by-products, soybean meal and molasses.

Copper (Cu)
Major functions - Along with iron and B_{12}, copper helps in hemoglobin formation. It is essential in some enzyme system activation, hair development and pigmentation, wool growth, bone development, reproduction, and lactation.

Deficiencies - Symptoms of copper deficiency include severe diarrhea, slow growth caused by anemia, swelling of joints, swayback in newborn lambs, difficulty in breathing, loss of hair color in cattle, and abnormal wool growth in sheep. Milk is low in copper; therefore, young animals raised solely on milk may develop anemia.

Interrelationships - Only small amounts of copper are needed by the animal; however, the level required is influenced by the amounts of iron, manganese, zinc, lead, nitrate, and molybdenum in the ration.

Toxicity - Copper levels above 250 ppm are toxic with death resulting. Levels above 50 ppm are considered potentially dangerous to animal health. Excessive amounts of copper accumulate in the liver and may result in death. Other toxicity symptoms include anemia and jaundice.

Sources - Most livestock feeds have 3-4 times the amount of copper needed by animals. Also, a variable store of copper is located in the liver and spleen. If needed, use commercial minerals or trace-mineralized salt containing copper sulfate. Commercial minerals fed to sheep should not contain copper because it may be lethal. Copper accumulates in bodies and does not metabolize.

Fluorine (F)
Major functions - Fluorine helps prevent cavities in teeth and possibly slows osteoporosis in older animals.

Deficiencies - Fluorine deficiency in the diet is rare, and supplements are not recommended. However, large amounts of calcium, aluminum or fat will lower the absorption of fluorine. Drinking water and forages usually contain enough fluorine to meet livestock needs.

Interrelationship - High dietary calcium depresses fluorine uptake in bone.

Toxicity - In excessive amounts, fluorine is toxic. The symptoms of too much fluorine in the diet develop slowly over time because fluorine is a cumulative poison. High levels will result in enlarged bones; softening, mottling and irregular wear of the teeth; a roughened hair coat; delayed maturity; and less efficient utilization of feed.

Iodine (I)
Major functions - Iodine is necessary for the production of the hormone thyroxine in the thyroid gland. This hormone controls the rate of oxidation of nutrients in the cells, and thus controls heat production in the animal's body.

Deficiencies - A deficiency in iodine reduces the production of thyroxine and leads to goiter (the enlargement of the thyroid gland). Enlargement of the thyroid gland is nature's way of trying to make enough thyroxin when there is insufficient iodine in the diet. There is no satisfactory treatment for animals that have developed pronounced iodine deficiency symptoms. Other deficiency symptoms include stillbirths and weak young; hairless pigs and wool-less lambs at birth.

Toxicity - Long-term chronic intake of large amounts of iodine reduces the thyroid uptake of iodine.

Sources - Good sources of iodine include iodized salt, calcium iodate, whey, and molasses.

Iron (Fe)

Major functions - Iron is necessary for hemoglobin formation and is also involved in oxidation of nutrients in the cells. (Hemoglobin is the part of the blood that transports oxygen to the cells in the body.) Other minerals needed for hemoglobin formation are copper and cobalt.

Ration requirements and deficiencies - The amount of iron required in the diet is believed to be as little as 80 mg per kg of diet for most animals. Livestock feeds generally contain enough iron to meet the needs of older animals.

Milk is low in iron; therefore, iron deficiency occurs with young, nursing animals. Iron deficiency occurs more frequently with nursing pigs raised in confinement than with other species. Other young appear to have sufficient reserves of iron in the liver and spleen to carry them through the nursing period. Oral doses or injections of iron for young pigs are necessary to prevent anemia, which is the most common symptom of iron deficiency.

Symptoms of anemia in young pigs include labored breathing; listlessness; pale eyelids, ears, and nose; and flabby, wrinkled skin. A concentrated ferrous sulphate or other iron solution can be given to young pigs orally. An iron dextran injection of 150-200 mg at three days of age can be used instead of oral administration.

Interrelationships - Too much iron in the diet will interfere with the assimilation of phosphorus because of the formation of insoluble iron phosphates. Copper is required for proper iron metabolism to occur.

Sources - Legumes and leafy plants contain enough iron to meet the needs of older animals. Trace-mineralized salt containing iron should be fed to all livestock to prevent iron deficiency.

Manganese (Mn)

Major functions - Manganese is essential for normal bone formation and growth of other connective tissue. It is also involved in enzyme systems that influence estrus, ovulation, fetal development, milk production, and growth. Manganese also functions in the synthesis of fatty acids, amino acid and cholesterol metabolism, and in blood clotting.

Deficiencies - A ration is manganese deficient when the level of manganese drops below 20 ppm. Indications of low manganese levels in the diet are: poor growth, abnormal bone development, sterility, delayed estrus, reduced ovulation, abortions, pinkeye, and slipped tendon in poultry. Swollen and stiff joints are evidenced by knuckling over (in calves) and crooked legs and enlarged hocks (in pigs).

Interrelationships - The normal range of manganese is 50-150 ppm. Levels in excess of 500 ppm will cause problems with phosphorus and iron utilization. Excess calcium and phosphorus decrease manganese absorption.

Sources - While the availability of manganese is not as good from manganese sulphate or manganese oxide, these inorganic sources can be used to add manganese to the ration. Most livestock rations have enough manganese, with roughages having higher levels than grain and corn being low. Beef cattle on all-concentrate diets based on corn and NPN supplements might need manganese supplements in the diet. Corn and soybean meal rations for swine can be improved with manganese supplements.

Molybdenum (Mo)

Major functions - Molybdenum is a component of an enzyme found in milk and in body tissues. It is also involved in stimulating rumen organisms.

Molybdenum is also part of three different enzyme systems involved in the metabolism of carbohydrates, fats, proteins, and iron.

Interrelationships/toxicities - Utilization of molybdenum is reduced by excess copper sulfate and tungsten. Molybdenum is related to uric formation in poultry and microbial action in ruminants. Toxic levels of molybdenum interfere with copper metabolism. Toxicity symptoms include severe scours and loss of condition.

Selenium (Se)
Major functions - Selenium is needed in small amounts because of its relationship with vitamin E absorption and utilization. Selenium prevents degeneration and fibrosis of the pancreas in chicks. Most importantly, it protects tissue against certain poisonous substances, such as arsenic, cadmium, and mercury.

Deficiencies - A deficiency of selenium causes nutritional muscular dystrophy (white muscle disease) in cattle, sheep, chickens, swine, and horses. It may also cause liver damage in swine.

Toxicity - Three types of selenium toxicity occur in livestock: acute, chronic blind staggers, and chronic alkali-disease. Symptoms include blind staggers, lameness, anemia, excess salivation, grinding of the teeth, and blindness. Excess selenium in poultry results in reduced egg production and deformities such as lack of eyes and deformed wings and feet.

Sources - Good sources of selenium include marine by-products, such as seaweed and kelp, cereal grains and wheat by-products.

Silicon (Si)
Major functions - Silicon is necessary for normal growth and skeletal development of chicks.

Deficiencies - A deficiency of silicon in a chick's diet results in slow growth and skeletal deformities, especially in the skull.

Sources - Silicon is present in large amounts in soil and plants. Also, on purified diets, the addition of silicon to the diet has increased the growth rate of chicks.

Zinc (Zn)
Major functions - Zinc is important for the normal development of skin, hair, wool, feathers, bones, and eyes; preventing parakeratosis; and healing wounds. Zinc is necessary in several enzyme systems, for protein synthesis and metabolism, and as an insulin component. Zinc also gives bloom to the hair coat.

Deficiencies - Symptoms of zinc deficiency in livestock include rough, thick skin in swine (commonly called parakeratosis); thickening of skin on the neck; loss of hair; wool slipping; poor feather development; slow wound healing; and poor appetite and growth.

Interrelationships - Excess calcium reduces the absorption and utilization of zinc. Animals are generally tolerant of excessive levels of zinc in the ration, although high levels will interfere with the utilization of copper and iron and might cause anemia. If the ration is high in zinc, additional copper and iron may be needed. Grains and forages seldom contain excessive levels of zinc, even if grown on soils with high levels of available zinc.

Sources - Zinc is often added in trace-mineralized salt for all livestock to ensure against a possible deficiency. Swine rations usually have zinc added to the ration. Other sources include fish meal, corn gluten feed, and meal and poultry by-products.

Absorption of Minerals in the Body

Dissolved minerals are absorbed into the bloodstream through villi in the small intestine. In the large intestine, nutrients are absorbed directly into the bloodstream through capillaries in the wall of the intestines.

Summary

At least 18 mineral elements are needed by animals. Those needed in large amounts are referred to as major or macro-minerals, while those needed in small amounts are called trace or micro-minerals. Minerals are required for the development of bones and teeth, as well as for many other functions in the body. Deficiencies cause lower production and poor gains, but rarely cause diseases or death. Commercial feeds and mineral mixes are the most common sources of minerals in livestock rations. Minerals can be mixed in complete feeds or fed free choice.

Credits

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Gillespie, James R. *Animal Nutrition and Feeding.* Albany, NY: Delmar Publishers, Incorporated, 1987.

Largen, Velda L. *Guide to Good Food.* South Holland, IL: Goodheart-Willcox Company, Inc., 1988.

Williams, James E. *Animal Science 202: Principles of Animal Nutrition Handbook.* University of Missouri-Columbia: Animal Science Department, 1990.

Lesson 6:
Vitamins' Role in Animal Nutrition

Vitamins are organic compounds that are essential for normal growth and maintenance of animal life. Only small amounts of vitamins are needed because they function as catalysts (parts of enzymes or coenzymes) in metabolic processes. Vitamins are distinct from carbohydrates, fat, protein, minerals, and water.

Classification of Required Vitamins

In animal nutrition, 16 vitamins are essential. These vitamins are classified by their solubility (whether they dissolve in water or in fat).

Fat-soluble - These vitamins can be stored in the animal's fat tissue, reducing the need for a daily supply in the diet. This enables livestock to survive on vitamin-deficient diets for longer without deficiency symptoms. Included in this group are Vitamins A, D, E, and K.

Water-soluble - Water-soluble vitamins are generally stored in the animal's body for only 2-4 days. Therefore, these vitamins need to be supplied regularly in the diet. Water-soluble vitamins include inositol, niacin, vitamins C, B_1 (thiamin), B_2 (riboflavin), B_3 (pantothenic acid), B_6 (pyridoxine), B_{12}, biotin, choline, folic acid, and para-aminobenzoic acid (PABA).

Vitamins are available to animals in protein supplements, mineral and vitamin supplements, and commercially prepared complete feeds. Feed tags show guaranteed minimum and maximum percentages of calcium, minimum percentage of phosphorus, and minimum and maximum percentages of salt in the feed. Vitamins are usually added to mixed rations or provided free choice.

Fat-Soluble Vitamin Functions, Deficiencies and Sources

Vitamin A

Major functions - Functions include normal maintenance of the eyes and epithelium (membrane) tissue of the respiratory, digestive, urogenital systems, and the skin. Vitamin A is also needed for normal bone growth, body growth and normal tooth development.

Deficiencies - Night blindness (inability to see in dim light) is a symptom of severe vitamin A deficiency. Vitamin A is a part of the visual purple of the eye, which is depleted through the action of light. Visual purple is required for vision in dim light. Animals suffering from night blindness will recover when sufficient amounts of vitamin A are added to the diet. Animals can become permanently blind when vitamin A deficient.

Excessive watering of the eyes and development of cornea ulcerations are also indications of possible vitamin A deficiency. Other indications include nervous incoordination shown by a staggering gait, diarrhea, reduced appetite, poor growth and weight loss. Also, unsound teeth and rough, dry skin may be a sign of vitamin A deficiency. Paralysis of some parts can occur in some species. Young animals suffer from deficiency sooner because of their greater requirements and reduced storage ability.

Reproductive problems include poor conception rates, reduced fertility in males, shortened gestation periods, and increased retained placenta. In poultry, discharges from the eyes and nostrils can occur, as well as wobbly gait in chicks, reduced egg production and hatchability of eggs.

Sources - Vitamin A can be provided as a synthetic vitamin or as carotene. Vitamin A itself is only present in animals, but plants contain the precursor, carotene. Carotene is found in good quality, fresh, green forages in generally sufficient amounts. Excellent sources of carotene are green, leafy hays that have been in storage less than one year; dehydrated, pelleted legume hays; and good quality grass or legume silages. Other carotene sources include yellow corn, fish liver oil, dehydrated alfalfa meal and whole milk.

Storage in the body - Vitamin A is stored in the liver and fatty tissues of the body. The animal can use stored vitamin A when the diet is deficient in carotene.

Ration considerations - Conditions that might indicate a need for vitamin A supplements include (1) poor quality or low levels of forages,

(2) limited amounts of colostrum or whole milk in the diet, (3) diets of corn silage and low-carotene concentrates, (4) grazing during drought periods, and (5) rations made up mainly of cereal grains, except corn.

Additional comments - Vitamin A and carotene are readily destroyed by oxidation, thus resulting in considerable losses in processing and storing (such as in making and storing hay).

Vitamin D
Major functions - Vitamin D is important for calcium absorption and phosphorus metabolism in the body. Rickets is prevented by vitamin D, along with calcium and phosphorus. Vitamin D also promotes sound teeth.

Deficiencies - A shortage of vitamin D will result in rickets in young or osteoporosis in adults with insufficient calcification of the bones. However, less vitamin D is required when a good balance of phosphorus and calcium is present. Symptoms of vitamin D deficiency are decreased appetite, slower growth, digestive disturbances, stiffness in gait, and sometimes the development of tetany and convulsions. As the disease progresses, joints enlarge and become swollen and stiff. Pregnant animals might give birth to dead, weak or deformed young because of vitamin D deficiency. Chickens will show rickets, poor feathering and growth with a reduction of egg production, hatchability and poor eggshells in laying hens.

Sources - Diets that include sun-cured forages generally provide sufficient vitamin D. Animals regularly exposed to sunlight or ultraviolet light will not develop deficiency symptoms. Green forages, barn-cured hay, and silages have some vitamin D. Grain, grain by-products, and protein feeds have almost no vitamin D.

Additional comments - When animals are exposed to direct sunlight, the ultraviolet light in the sunlight penetrates the skin and produces vitamin D from traces of certain cholesterol in the tissues. However, tissue storage of vitamin D is very limited.

Vitamin E
Major functions - Vitamin E functions as an anti-oxidant, which helps in absorption and storage of vitamin A. As an antioxidant, it also acts in other metabolic functions in the cell. Vitamin E is essential for the integrity of red blood cells and in cellular respiration, primarily in heart and skeletal muscle tissues. It is also a regulator in the synthesis of DNA and vitamin C.

Deficiency symptoms - Vitamin E deficiency looks similar to selenium deficiency--white muscle disease or nutritional muscular dystrophy. Hatchability of eggs is reduced, although production does not appear to be affected. Extended vitamin E deficiency in poultry will cause permanent sterility in the male and reproductive failure in the female. The addition of selenium to the diet can prevent some symptoms of vitamin E deficiency.

Sources - Good dietary sources of vitamin E include whole cereal grains, the germ or germ oils of cereal grains, green forages, alfalfa meal, rice polishings, wheat germ meal, and good quality hay. After a long storage period, the vitamin E level in feeds declines. It is rapidly destroyed when near rancid fat. Vitamin E is seldom deficient in the diet unless feeds were produced on selenium-deficient soils. Vitamin E is produced commercially and can be added to the diet when needed by using a vitamin premix or injecting into the muscle.

Additional comments - Vitamin E is widely distributed in all natural feeds. Utilization of vitamin E depends on adequate selenium. There is some storage of vitamin E in the liver and other fatty tissues.

Vitamin K
Major function - Vitamin K is necessary for the formation of prothrombin in the blood, which helps blood clot.

Deficiencies - Vitamin deficiencies K rarely occur because it is synthesized in the rumen and in the intestinal tract of monogastric animals. Feeding moldy feeds with a high dicoumarol content, such as moldy sweet clover, might cause a vitamin K deficiency. This can lead to a bleeding syndrome called sweet clover poisoning or bleeding disease. Moldy feeds with a high dicoumarol content fed to swine or poultry will also cause internal bleeding and death. Feeding vitamin K or water-soluble synthetic forms of the vitamin will counteract deficiency effects.

Sources - Dietary sources of vitamin K include green, leafy feeds (either fresh or dry); fish meal; liver; and soybeans. Vitamin K is usually widely available in normal farm rations, and is synthesized by all classes of farm animals. However, it is common to add vitamin K to swine diets and chick starter rations.

B Complex Vitamins: Functions, Deficiencies and Sources

Ruminants (cattle, sheep, goats) generally do not need vitamin B complex supplements. Microorganisms in the functioning rumen synthesize many of these vitamins, and feeds used in ruminant nutrition also supply many B complex vitamins.

However, the rumen does not function in young animals, so supplements are recommended if the young animal is not nursing. Mother's milk contains many B vitamins needed by the young.

Biotin
Major functions - Biotin is required in many reactions in the metabolism of carbohydrates, fats and proteins. Biotin serves as a coenzyme for transferring carbon dioxide from one compound to another. It is also a coenzyme for the production of energy.

Deficiencies - Deficiency symptoms include dermatitis, loss of hair, cracks in the feet, slow growth, hind leg spasticity in swine, and reduced hatchability of eggs.

Sources - Feed sources of biotin include most grains (except wheat and barley), soybean meal, green forages, alfalfa meal, synthetic biotin, and black strap molasses. Animals can readily synthesize biotin, and it is generally not deficient in normal rations. Biotin is available in commercial vitamin premixes.

Choline
Major functions - Choline is a structural component of fat and nerve tissue and is required in the diet at levels higher than other vitamins. It functions as a part of the cell structure, lipid transport, nerve impulse transmission, and fat metabolism in the liver.

Deficiencies - Choline deficiency symptoms include slow growth rate, unthriftiness, fatty livers, poor coordination, reproductive problems, lower milk production, and higher death rate in the young. It can also result in slipped tendons in chickens and turkeys. In swine, an abnormal gait and reproductive failure in adult females may develop. Deficiency symptoms are more visible as the protein content is lowered.

Sources - Good dietary sources of choline include meat scraps, canola meal, fish meal, soybean lecithin, and yeast. Some grains, forages, and dairy byproducts contain lesser amounts of choline. Most farm rations contain enough choline. It is synthesized in the body when there is sufficient protein and other vitamins, especially vitamin B_{12}.

Folic acid
Major functions - Folic acid is a part of the folate coenzymes; it is key to the normal function of body cells and essential amino acid formation. Folic acid is involved in the combining of single carbon units into larger molecules. It is closely related to vitamin B_{12} metabolism, and deficiencies of either one affect the function of the other.

Deficiencies - Shortages of folic acid result in weakness, slow growth, and anemia. Additional signs in young chicks include reduced growth, depigmentation of colored feathers, and poor feathering. In breeding hens, the result is lower egg production and hatchability.

Sources - Green pasture; green, leafy alfalfa hay; soybean meal; wheat germ; and cottonseed meal are good dietary sources of folic acid. Synthetic folacin is readily available when dietary supplements are needed, although for most animals, there is generally enough available through the diet and synthesis in the body.

Thiamine (B_1)
Major functions - Thiamine functions as a coenzyme in energy metabolism and is involved in peripheral nerve functioning. Thiamine helps

maintain a normal appetite, muscle tone and a healthy mental attitude.

Deficiencies - Utilization of thiamin is hindered by high fat diets. Indications of thiamine deficiency are anorexia, slow growth, weakness, increased irritability, lowered body temperatures, slower heartbeat, and enlargement of the heart. In laying hens, egg production is lowered.

Sources - Dietary sources of thiamine include cereal grains; grain byproducts; brans; green, leafy hay; green pastures; and milk. Infection of grains with certain kinds of mold can destroy the thiamine content. Thiamine is unstable when heated; therefore, drying grain or cooking soybeans reduces the amount of available thiamine in these feeds. Except for ruminants like cattle, sheep, and goats, all animals must have a dietary source of thiamine. It is also available in commercial vitamin premixes.

Riboflavin (B_2)

Major functions - Riboflavin promotes growth and functions as a constituent of several enzyme systems. It is also important in carbohydrate, fatty acid, and amino acid metabolism.

Deficiencies - Indications of riboflavin deficiency include slow growth in most species; poor reproduction and lower milk production in sows; anemia, diarrhea, vomiting, eye cataracts, stiffness of gait in young pigs; lesions around the mouth and loss of hair in calves; curled-toe paralysis in young chicks; and periodic moon blindness in horses.

Sources - Dietary sources of riboflavin include synthetic riboflavin; milk; green, leafy hay (especially alfalfa); green pastures; and grass silage. Riboflavin is commercially available in vitamin premixes. Ruminant rations may need riboflavin supplements, and swine and poultry rations generally have riboflavin added.

Additional comments - Grains are considered poor sources of riboflavin. Riboflavin is destroyed by light or heat.

Pantothenic acid (B_3)

Major functions - Pantothenic acid is a component of coenzyme A, which is important in energy metabolism and is required by the cells in the biosynthesis of fatty acids.

Deficiencies - In all species, deficiency symptoms include slow growth, loss of hair, and enteritis (inflammation of the intestine). In young pigs, it results in stiff legs, lack of coordination, and poor condition of the hair and skin. Young chicks will have extremely ragged feather development and lesions on the mouth. B_3 deficient calves show a rough coat, dermatitis, anorexia, and loss of hair around the eyes. (Mature ruminants synthesize vitamin B_3 in the rumen.)

Sources - Good feed sources of pantothenic acid include brewer's yeast, cane molasses, dried milk, alfalfa meal, and whey. Grains are deficient in this vitamin, and deficiencies are most likely to appear when confinement animals eat high grain diets. Mature ruminants synthesize pantothenic acid. However, pantothenic acid is commonly added to commercial swine and poultry rations.

Pyridoxine (B_6)

Major functions - Pyridoxine is a component of amino acid coenzymes and essential fatty acid metabolism. It assists in the production of red blood cells and in the endocrine system. Pyridoxine is a coenzyme in protein and nitrogen metabolism.

Deficiencies - Indications of pyridoxine deficiency are anorexia, slow growth, and convulsions in all species; anorexia and poor growth in pigs; abnormal feathering and stunted growth in chicks; and lower egg production, poor hatchability, rapid weight loss, and eventually death in hens.

Sources - Dietary sources of pyridoxine include cereal grains (especially wheat) and grain byproducts; green pastures; and green, leafy hay (especially alfalfa). Livestock rations generally do not need pyridoxine supplements. Pyridoxine is synthesized in the rumen of cattle, sheep, and goats and perhaps in the cecum of the horse.

Vitamin B_{12}

Major functions - Vitamin B_{12} is needed for red blood cell maturation and functions as a coenzyme in a variety of metabolic reactions. Cobalt is found in vitamin B_{12} and must be present for synthesis of the vitamin to occur. This is the only function of cobalt in the animal's body.

Deficiencies - A B_{12} deficiency is shown by slow growth in all species; lack of hind leg coordination in young pigs; reduced litter size and higher pig death rate in breeding swine; and lower egg hatchability in breeding chickens.

Sources - Good dietary sources of vitamin B_{12} include synthetic B_{12}, animal proteins, and fermentation products. Vitamin B_{12} is also available in commercial vitamin premixes. It is apt to be lacking in swine and breeder poultry rations.

Para-aminobenzoic acid

Functions and deficiencies - Para-aminobenzoic acid is essential for the growth of some microorganisms and is an essential part of the folacin molecule. Deficiency symptoms have not been observed in animals.

Sources - Para-aminobenzoic acid is synthesized readily in the intestine tract and is usually not deficient in livestock rations. Dietary sources include lecithin, soybean meal, peanut meal, and synthetic PABA.

Functions, Deficiencies and Sources of Other Water-Soluble Vitamins

Inositol

Functions and deficiencies - In combination with choline, inositol prevents hardening of the arteries and protects the heart. It also helps reduce blood cholesterol. Deficiency symptoms are not demonstrated in animals.

Sources - Inositol is synthesized in the intestinal tract and is generally not deficient in the diet. Dietary sources include synthetic inositol, yeast, and liver meal. Inositol is widely distributed in animal feeds.

Niacin

Major functions - Niacin is an essential part of two coenzymes necessary in cell respiration. It is also necessary for the release of energy from carbohydrates, fats, and proteins.

Deficiencies - General indications of deficiency include poor appetite, slow growth, and unthriftiness. In addition, swine show signs of diarrhea, vomiting, ulcerated intestines, dermatitis, and loss of hair. Niacin-deficient chicks develop an inflammation of the tongue, mouth cavity, and upper esophagus; reduced feed consumption; and poor feather development.

Sources - Some niacin is available in feeds, with meat and bone meal being good sources and green alfalfa being a fair source. However, niacin in cereal grains is largely unavailable, so swine and poultry need dietary supplements of this vitamin.

Additional comments - Niacin is a dietary essential for pigs, chickens, and humans. It is synthesized in the digestive tract of ruminants; therefore, they do not need dietary niacin under most conditions.

Vitamin C

Major functions - Vitamin C is necessary for the formation of collagen, a gelatin-like protein that is the main constituent of the fibrils of connective tissue and bones. Vitamin C is required for the absorption and movement of iron, and in the metabolism of fats and lipids. It is also related to cholesterol control, sound teeth and bones, strong capillary walls, and healthy blood vessels.

Deficiencies - Vitamin C deficiency symptoms have not been observed in farm animals. Normally, they synthesize sufficient amounts in body tissues to meet their needs; therefore, it is not required as a supplement to their diet. However, if a deficiency does occur, its symptoms include scurvy (swollen, bleeding, and ulcerated gums), loosening of teeth, and weak bones. It has been shown that more vitamin C may be needed in times of stress.

Sources - Good sources of vitamin C include synthetic vitamin C, citrus pulp, well-cured hay, and green pasture. Usually, ordinary rations provide adequate vitamin C.

Summary

Vitamins are organic compounds essential for life but needed only in trace amounts. Sixteen vitamins have been identified as essential in animal nutrition. They are classified by their solubility--either fat-soluble or water-soluble. Fat-soluble vitamins can be stored in the body, reducing the need for dietary sources. Water-soluble vitamins are not generally stored in the body and must be supplied in the animal's diet. Vitamins play a vital role in various body system functions and are an important part of the animal's overall nutrition.

Credits

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Gillespie, James R. *Animal Nutrition and Feeding.* Albany, NY: Delmar Publishers, Incorporated, 1987.

Largen, Velda L. *Guide to Good Food.* South Holland, IL: Goodheart-Willcox Company, Inc., 1988.

Williams, James E. *Animal Science 202: Principles of Animal Nutrition Handbook.* University of Missouri-Columbia: Animal Science Department, 1990.

Lesson 7:
Water's Role in Animal Nutrition

Water is a very important component in animal nutrition. An animal cannot use proteins, energy, vitamins, and minerals without water. This also applies to humans. Water makes up 50-75 percent of the weight of the human body. It also helps human digestion, cell growth, chemical reactions, body temperature regulation, and joint lubrication. Lack of water creates kidney failure, fever, increased pulse rate, and flushed skin in the human body. Similar functions apply to livestock, as well.

Functions of Water

In livestock, water has many functions. It serves as a body fluid throughout the animal's body. Body fluids are present at every joint in the skeletal system to aid in joint lubrication. Body fluids also lubricate the eyes so they can rotate within sockets, and body fluids accumulate around nerves to provide a cushion. In the ear, body fluids help conduct sound for hearing.

Water also dilutes toxic substances within the body. Undiluted urea can be very harmful, but watered-down urea is carried it safely through the urinary tract.

Water plays an important role in the circulatory system. It acts like a car radiator by transferring heat from one part of the body to another. Animals do not have sweat glands, so they do not perspire. Water cools bodies through evaporation through the animal's skin.

Animals produce gases as byproducts during respiration and digestion. Carbon dioxide and methane are two forms of gas byproducts. These gases are released when they are mixed with water vapor in the lungs and then exit through respiration. Therefore, water plays a major function during gas exchange in the animal's body.

If an animal has an inadequate water supply, it will soon develop a fever because of dehydration. Water plays an important role in regulating animal body temperature. A lack of water also decreases heat transfer, which aids in body temperature regulation.

How do animals recognize their food? How do humans recognize their food? Humans use sight most of the time, but sight can fool the other senses. Animals distinguish food through their sense of taste. Taste buds are used to evaluate food. Water carries chemicals in food to the taste buds so they can decide if it should be eaten. Palatability is extremely important in feeds, because if the animal's taste buds don't recognize the feed, it will not eat the feed.

Since water makes up 60-75 percent of an animal's body weight, it is obvious that the animal would lack form without water. Water maintains the animal's shape in several different ways. Blood consists mainly of water, and without water, blood would not flow. Living cells consist mainly of water, which are the building blocks in which life exists.

As previously mentioned, water plays an important role in blood by acting as a carrier of nutrients in the bloodstream. Without water, nutrients could not be carried to different parts of the body to be utilized.

The last function of water is the elimination of waste products. Byproducts of digestion are carried in urine, which consists of water. In the previous lesson, it was mentioned that water is absorbed to form fecal material. Some water also remains in fecal material to ease its move through the digestive tract.

Daily Requirements for Water

Factors - There are several factors that determine the daily requirements for water needs in animals. The type of species is an important consideration, since larger species like cattle require more water than sheep. Lactating species require more water than a dry species. Age also influences the daily requirements of water. A younger animal requires more water per pound of body weight because it has higher needs for body water. Younger animals have less bone and muscle mass than older animals.

Environment affects the daily requirements of an animal. When environmental temperatures increase, the need for water increases to maintain a constant body temperature. The amount of exercise an animal gets affects its daily water requirement. An active animal needs more water than a sluggish animal.

Moisture content of a feed also influences daily water requirements. An animal on a high grain diet will need more water than an animal grazing on a fresh green pasture.

Environmental temperature affects requirements, but so does humidity. The higher the environmental humidity, the greater the water intake. The level and kind of production of the animal (whether they are gestating or producing milk, meat, etc.) also affects daily water requirements.

If the mineral content is increased in the diet, the animal will increase the water intake.

Average daily requirements - Listed below are several average daily requirements needed by different species of livestock.

Beef cattle
  Growing cattle
    100 lbs. = 1.5 gallons
    400 lbs. = 5 gallons
    800 lbs. = 7 gallons
  Mature cattle
    Fattening = 9 gallons
    Lactating = 10-15 gallons
Lactating dairy cattle
  Average production = 12-25 gallons
  Heavy production = 35+ gallons
Growing sheep
  20 lbs. = .5 gallons
  50 lbs. = .4 gallons
  150-200 lbs. = 1+ gallons
Swine
  Growing swine
    50 lbs. = 1+ gallons
    100 lbs. = 1.5+ gallons
  Mature swine
    Pregnant = 5+ gallons
    Lactating = 6+ gallons

Sources of water - There are several sources of water that an animal can use. Drinking water is the first source. It must be fresh, clean, and provided at all times for the animal's use. Water provided by feeds is the second source. Each feed provides a different moisture content. Fresh green pastures have an 80 percent moisture content. Green cut forages, such as silage, have a 65-75 percent moisture content. Dry harvested forages, such as hay, have a 15 percent moisture content. Harvested grains, such as corn, have only 10-15 percent moisture content.

The last source is water produced by body metabolism. This source should not be figured in a ration, because it supplies an insignificant percentage of water. Water can be produced when fats, proteins, and carbohydrates are digested and metabolized.

Water Toxicity

What is water toxicity and how does it occur? Water toxicity is water dehydration accompanied by concentration of sodium and other ions in the brain cells that cause cerebral edema. Water toxicity occurs in animals that have been without water for a long time and suddenly have access to fresh water. The animal basically overdoses itself on water by drinking too much. Dehydrated body tissues can't handle the sudden overdose of water.

Water toxicity occurs more commonly in younger animals. As mentioned earlier, younger animals have a higher water content in their bodies because they lack muscle and bone mass. Younger animals will try to drink 35-50 percent of their body weight within a half hour period.

There are several symptoms that define water toxicity. They are hemoglobinuria (red urine), diarrhea, irregular heartbeat, body hair standing on end, excessive salivation, extended head and neck, nervous signs, and finally coma and death. Fluids usually collect in soft tissues under the skin and is most apparent as swollen and puffy eyelids.

The most noticeable symptom of water toxicity is the extension of the head and neck. This symptom is similar to a young calf sucking on its mother, with the neck extended and head laid back.

The animal also shows some nervous signs. It might have an unstable walk and appear disoriented. The animal might also excessively rub and lick its body.

If water toxicity is detected soon enough, treatment can be effective. Saline or hypertonic glucose can be given intravenously to remove excess water from body tissues. The animals can drink salt water to pull excess water from body tissues, but this must occur before animal drinks the initial overdose of water.

Water toxicity is a slow process, so there is time to correct its effects. It takes 4-6 hours for water toxicity to kill an animal. It is always smart to observe animals that haven't had fresh water for a long time for water toxicity symptoms. Observation is a good management practice when an animal breaks from its normal routine.

Effects of Inadequate Water Supply

An inadequate water supply means a lack of water, not an absence of water. Several things occur when animals have a low water intake or the water is not fresh. A lack of appetite signals an inadequate water supply. The less water an animal drinks, the less feed it eats. Remember, water plays an important role in digestion. Since a lack of appetite occurs, weight loss is also a sign of inadequate water supply. When an animal is losing weight, its performance and production are reduced considerably.

A lack of water causes the blood to thicken in the animal because water composes the highest percentage of blood. Inadequate water supply can be fatal because it leads to dehydration and water toxicity.

Good management practices also include knowing normal body functions that can influence water intake. If the animal develops scours or diarrhea, the water requirement increases because of the digestive disturbance. Respiration is a normal body function that affects an animal's water intake. During respiration, moist air is exhaled. Respiratory problems could occur if inadequate water supply is not provided. Regulating body temperature is another normal body function. In the animal's body, heat is transferred by the release of moist air through the skin. When the environmental temperature and humidity increase, so will the water intake of the animal.

Summary

Understanding the roles of nutrients is vital for the management of livestock. A deficiency in one or more nutrients can cause severe losses in the production of livestock. Water is critical in maintaining all animal body functions; understanding this concept will lead to success as a livestock producer.

Credits

Livestock Nutrition and Feeding (Student Manual). 2nd ed. Columbus, OH: Ohio Agricultural Education Curriculum Materials Service, 1991.

Cullison, Arthur Edison. *Feeds and Feeding.* Reston, VA: Reston Publishing Co., 1987.

Ensminger, M. E., and C. G. Olentine, Jr. *Feeds and Nutrition.* Clovis, CA: The Ensminger Publishing Company, 1990.

Largen, Velda L. *Guide to Good Food.* South Holland, IL: Goodheart-Willcox Company, Inc., 1988.

Lesson 8:
Environmental Effects on Nutrition

Environment simply means everything surrounding an animal--weather, shelter, other animals, nutrition, etc. These surroundings can and do affect growth, development, and production in all animals.

An Animal's Environment

Environmental control includes nutrition, space requirements, light, air temperature and velocity (wind), relative humidity, wet bedding, dust, ammonia buildup, odors, and manure disposal. Enhancing these factors can enhance animal performance.

Factors with the most impact on an animal's nutritional needs are nutrition, weather and facilities/shelter, health, and stress.

Weather's Effects on Nutrition Requirements

Webster's dictionary defines weather as a "state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness and cloudiness."

Animals have a thermo-neutral (comfort) zone (C to F in Figure 8.1). This is the range within which the animal can perform with little discomfort by using physical regulation (such as shivering or seeking shade). Extreme weather can cause wide fluctuations in animal performance.

An animal's requirements increase as temperature, humidity, and air movement (wind) exceed or fall short of the animal's comfort zone. These three factors also influence an animal's heat loss. Animals adapt to weather in the following ways.

Cold weather - In cold weather, heating mechanisms used include (1) increased insulation from growth of hair and more fat, (2) increase in thyroid activity, (3) seeking protective shelter and warming sunshine, (4) huddling together, (5) consumption of more feed, which increases the heat increment and warms the animal, and (6) increasing activity. The most important heating mechanisms are body activity and amount of feed consumed.

TABLE 8.1 - Comfort Zones of Animals

Class of animal	*Temperature*		*Acceptable humidity (%)*
	Comfort zone (°F)	*Optim. (°F)*	
Cattle			
Beef cow	40-70	50-60	50-75
Steer, enclosed building	40-70	50-60	50-75
Dairy cow	40-70	50-60	50-75
Dairy calves	50-75	65	---
Sheep			
Ewe	45-75	55	50-75
Feeder lamb	40-70	50-60	50-75
Newborn lamb	75-90	---	---
Swine			
Sow, farrowing house	60-70	65	60-85
Newborn pigs	80-90	85	60-85
Feeder/finishing	60-65	60	60-85
Horses			
Horse	45-75	55	50-75
Newborn foal	75-80	---	---
Poultry			
Layers	50-75	55-70	50-75
Broilers	85-95	70	50-75
Turkeys	95-100	---	---

Credit: Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992. Used with permission.

Hot weather - In hot weather, cooling mechanisms include (1) moisture vaporization (from the skin and lungs), (2) avoidance of the sunshine (seeking shade), (3) depression of thyroid activity, and (4) loafing (including lessening the production of meat, milk, and eggs, since they increase heat production).

The diagram in Figure 8.1 shows (1) influence of thermal zones and temperature on warm-blooded animals, and (2) the peak of milk yields in the spring, followed by the summer slump due to the high temperatures and lower-quality forages.

Heat production (metabolism) is plotted against ambient temperature to depict the relationship between chemical and physical heat regulation. Terms pertaining to Figure 8.1 follow.

Optimum temperature - This is the most comfortable temperature for the animal, and the greatest amount of energy can be used for production and feed efficiency (D to E in Figure 8.1).

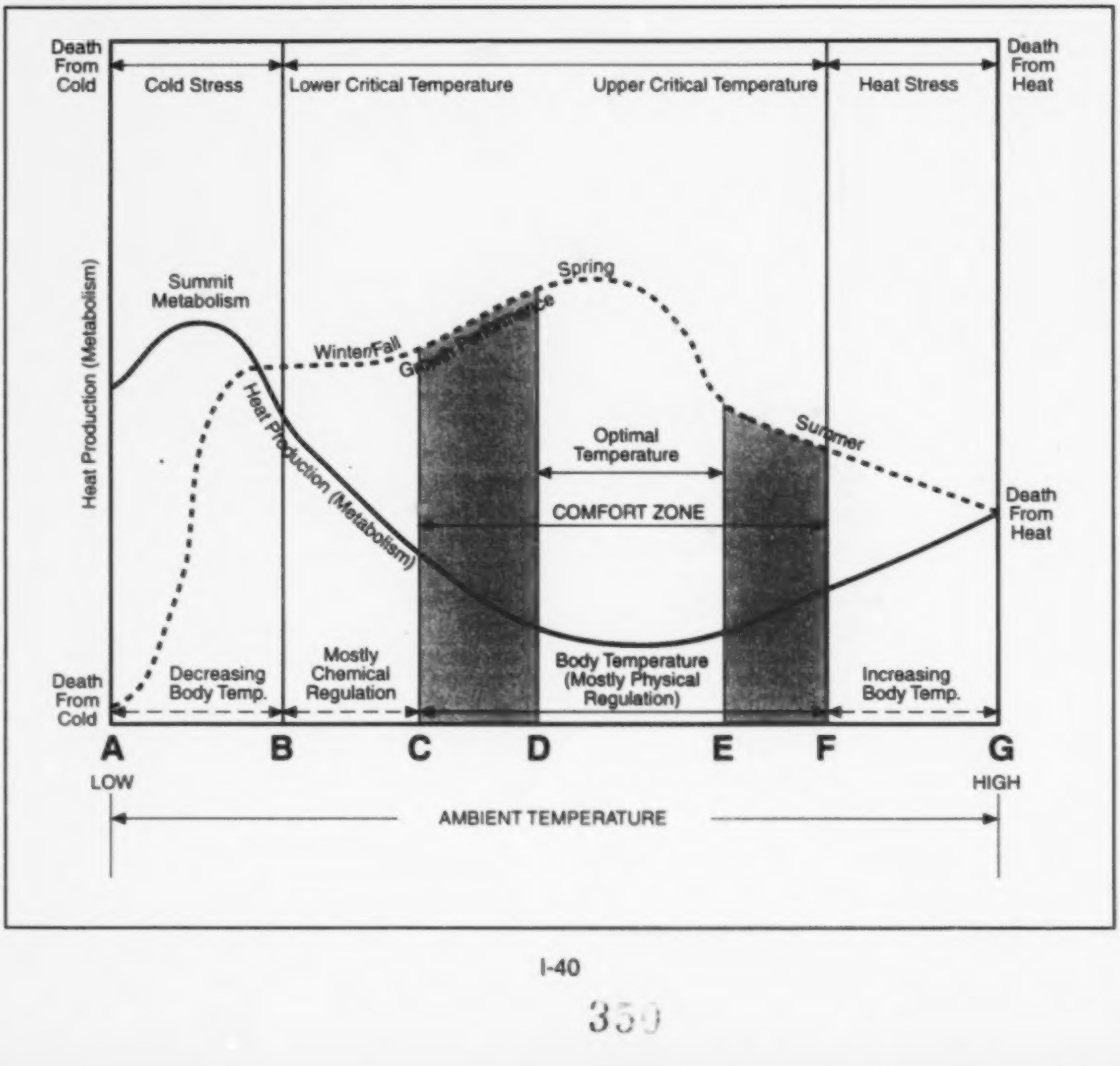
Lower critical temperature - The low point of the cold temperature beyond which the animal cannot maintain normal body temperature. In the zone below C, chemical temperature regulation is utilized (such as using fat deposits or increased respiration). When the environmental temperature reaches below point B, the chemical-regulation mechanism is no longer able to cope with cold. The body temperature then drops, followed by death.

Upper critical temperature - This temperature is the high point on the range of the comfort zone, beyond which animals are heat stressed and physical regulation cools them (F).

The cow produces the maximum yield of milk during the spring when the temperature is optimum (D to E) and the minimum yield in the summer when it is hot (F to G).

Comfort zone, optimum temperature, and both upper and lower critical temperatures vary. Factors include different species, breeds, ages, body sizes, physiological and production status,

FIGURE 8.1 - Thermo-Neutral Zone (Comfort Zone)



adaptations, climate, feed consumed (kind and amount), the activity of the animal, and the opportunity for evaporative cooling.

Animals that consume large quantities of roughage or high-protein feeds produce more heat during digestion; hence, they have a different critical temperature than the same animals fed a high-concentrate, moderate-protein ration. During hot summer months, experienced cattle feeders decrease the roughage and increase the concentrate of finishing cattle.

High humidity increases both high and low temperature stresses. There is less of a cooling effect from evaporating moisture and respired air. As humidity increases, discomfort and nutrient utilization decrease proportionately.

Air movement (wind) results in body heat being removed at a more rapid rate than when there is no wind. In warm weather, air movement can make the animal more comfortable, but in cold weather it adds to the stress temperature. (See Table 8.2.) At low temperatures, the nutrients required to maintain the body temperature are increased as the wind velocity (wind chill) increases.

Rain reduces feed intake by 10-30 percent. Mud reduces feed intake by 5-30 percent, depending upon its depth and the amount of bedded area.

There are several ways in which animals cope with inclement weather. These include adaptation, environmentally controlled buildings, and increased/decreased nutrient needs. Adaptation is shown by Brahman cattle being more heat tolerant and British breeds, such as Herefords, being more cold tolerant.

Other Factors Affecting Nutritional Needs

Gestation - Nutrient requirements for pregnant females are most critical during the last third of the gestation period (trimester), when the developing fetus grows most. Especially critical are nutrient requirements for young females during the first pregnancy. Poor nutrition at this stage will result in a poorly developed fetus and poor growth of the mother.

Lactation - Producing milk requires a liberal supply of energy, protein, minerals, and vitamins in the ration. After giving birth, feed requirements increase tremendously because of milk production. A female suckling young needs approximately 50 percent greater feed allowance than during the pregnancy period.

TABLE 8.2 - Wind-Chill Factors for Cattle with a Winter Coat

Wind speed (mph)	Temperature (°F)										
	-10	-5	0	5	10	15	20	25	30	35	40
5	-16	-11	-6	-1	3	8	13	18	23	28	33
10	-21	-16	-11	-6	-1	3	8	13	18	23	28
15	-25	-20	-15	-10	-5	0	4	9	14	19	24
20	-30	-25	-20	-15	-10	-5	0	4	9	14	19
25	-37	-32	-27	-22	-17	-12	-7	-2	2	7	12
30	-46	-41	-36	-31	-26	-21	-16	-11	-6	-1	3
35	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	-10
40	-78	-73	-68	-63	-58	-53	-48	-43	-38	-33	-28

Credit: Taylor, Robert E. *Beef Production and Management Decisions.* 2nd ed. New York: MacMillan Publishing Co., 1994, p. 333. Reprinted by permission of Prentice Hall, Upper Saddle River, N.J.

Stress - Stress is any environmental factor that is counter-productive to an animal's well-being, either external or internal. Animals under stress demand the very best nutrition.

Many kinds of management-related stress affect animal production: excitement, the presence of strangers, changing animals that are together, crowding, disease, hauling, how animals are handled, and weaning.

The right kind of animal handling can reduce stress. Preconditioning reduces the amount of stress present at weaning. It involves starting young animals on feed and vaccinating them before weaning. Proper handling during vaccinations, movement, and hauling can greatly reduce stress and its results.

Health - Health is the state of complete well-being--not merely the absence of disease. It is estimated that animal diseases and parasites in the U.S. decrease animal productivity by 15-20 percent. Nutrition could be involved in 85 percent of veterinary-treated cases.

Muddy lots - Muddy lots often plague livestock producers, especially during the winter months. Mud increases scours and other diseases in newborn animals and reduces production and feed efficiency in older animals. California Agricultural Experiment Station studies show that mud can reduce finishing cattle gains and increase the feed required per pound of gain by 10-35 percent.

It is important to minimize this problem by picking a location for the feedlot that allows for proper drainage. Mounds that are 6-12 feet high provide finishing cattle a dry place on which to lie. Also, lessening the number of cattle in the feedlot during the muddy periods is an effective method of controlling the mud problem.

Temperature's Effect on Feed Requirements and Production Yields

Dairy cattle - The optimum temperature for the production of milk is 55-64°F. Temperatures below optimum result in a reduced water intake and approximately 35 percent increase in feed intake (down to -4°F). There is a corresponding reduction in milk production. This decrease can be corrected by increasing the proportion of concentrate in the diet (20 percent roughage/80 percent concentrate) and providing shelter. Higher concentrate levels help maintain milk yield without excessive loss of body weight.

Temperatures above the optimum result in an increase in water intake, a decrease in feed intake at 77-81°F, with greater decrease above 85°F. There is a decrease in dry-matter intake and a corresponding decrease in milk yield. At 95°F, milk yield might drop as much as 33 percent. Using confined housing for lactating dairy cows will help reduce the impact of weather extremes.

Beef cattle - The temperature range of 59-77°F is best for beef production. Variations from this range change feed intake as follows:

1. 77-95°F: depressed feed intake 3-10 percent
2. 41-59°F: increased feed intake 2-5 percent
3. 23-41°F: increased feed intake 3-8 percent
4. 5-25°F: increased feed intake 5-10 percent
5. Below 5°F: increased feed intake 8-25 percent

During cold weather, increase the amount of roughage for cattle on a restricted feed intake. However, with cattle on full feed, increasing the amount of roughage during cold weather can *decrease* the amount of energy available, thus reducing productivity.

Sheep - There is little experimental data available for sheep that describes the interaction of temperature and feed intake. Sheep can tolerate colder climatic extremes than other animals. Fleece length and the feeding level affect feed intake as temperatures change. Sheep need higher energy intake during cold stress. This can be economically met by increasing the roughage in the ration. During hot weather, decrease the roughage to lower the amount of heat produced by digesting the feed.

Swine - A temperature range of 64-70°F is considered optimum for growing/finishing swine. For each 1.8°F of temperature drop, the feed requirement increases 1-1.4 oz. daily. Heavier hogs are more sensitive to hot weather than lightweight hogs.

Poultry - Laying hens can adjust to a fairly wide range of temperatures. When temperature change occurs, feed intake will change temporarily and then return to approximately the level before the temperature change. Adequate drinking water is more critical for poultry growth or productivity. Compared to water intake at 70°F, water intake is doubled at 90°F and is 2.5 times greater at 98°F.

Summary

Livestock nutrient requirement tables are generally based on the assumption that no environmental stress is present. Feed and nutritional requirements need adjusting for changes in the animal's environment. Efficiency of nutrient use is affected by the weather and facilities, stress, and health.

Credits

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Gillespie, James R. *Animal Nutrition and Feeding*. Albany, NY: Delmar Publishers, Incorporated, 1987.

Largen, Velda L. *Guide to Good Food.* South Holland, IL: Goodheart-Willcox Company, Inc., 1988.

Taylor, Robert E. *Beef Production and Management Decisions.* 2nd ed. New York: MacMillan Publishing Co., 1994.

Williams, James E. *Animal Science 202: Principles of Animal Nutrition Handbook.* University of Missouri-Columbia: Animal Science Department, 1990.

Lesson 9:
Formulating and Balancing Rations

An animal must receive the proper amounts of nutrients in the right proportion to efficiently produce meat, milk, eggs, wool, work, etc.

General Principles in Formulating Rations

A ration is balanced when it provides the nutrient needs of the animal in the proper proportions. Balanced rations have nutrient allowances that are only 1-3 percent below the animal's requirement. Nutrient requirements are listed in tables usually available from the National Research Council. Diets must include a minimum level of dry matter for proper digestive tract functioning. Diets are commonly balanced to meet the protein, energy, calcium, phosphorus, and vitamin A requirements for the animal. Also, the cost of the nutrients should be considered when formulating a ration.

Protein - The amount of protein in the diet can be measured by crude protein (CP) or digestible protein (DP) content. For nonruminants, include essential amino acids in the ration. It is acceptable to have the protein content of the formulated diet as much as 5-10 percent above the nutrient requirements listed in the tables. However, remember that protein is an expensive part of the diet; using excessive amounts will substantially raise the cost of the ration.

Crude protein refers to all of the nitrogenous compounds in a feed. It is determined by finding the nitrogen content and multiplying the result by 6.25. The nitrogen content of protein averages about 16 percent. Not all crude protein is digestible.

Digestible protein refers to a ration's approximate amount of protein available for use by the animal. Digestible protein is the difference between the feed's protein content and what is found in feces. About 60 percent of a roughage ration and 75-85 percent of a high-concentrate ration is digestible.

Energy - Four measures of energy commonly used when formulating diets are digestible energy (DE), total digestible nutrients (TDN), metabolizing energy (ME), and net energy (NE). The energy provided in the diet should not be more than about five percent above requirements because animals are limited in the total amount of energy they can use.

Digestible energy is equal to the gross energy of the feed consumed minus the gross energy excreted in the feces.

Total digestible nutrients include the totals of the digestible protein, digestible nitrogen-free extract, digestible crude fiber, and 2.25 times the digestible fat.

Metabolizing energy is the gross energy of the feed consumed minus the energy in the feces, urine, and gaseous products of digestion.

Net energy includes the metabolizable energy minus the heat increment (heat used for digestion or metabolism). It is the energy used for growth, maintenance, production, work, fetal development, and heat production.

Minerals - Calcium and phosphorus are the two minerals generally needed in larger amounts. The ratio of calcium to phosphorus (between 1:1 and 2:1) is just as important as the total amount being fed. Other mineral needs of the animal are generally not considered when balancing rations. There are usually enough minerals provided in the ingredients used or by the addition of trace-mineralized salt.

Vitamins - A vitamin supplement is usually added to the ration to meet the animal's vitamin needs. However, vitamin A requirements might be considered in balancing rations. When low-quality legume hay is included in the diets of pregnant cattle or sheep, a vitamin deficiency can occur. Always add a vitamin supplement to a gestation ration.

Cost of nutrients - The cost per pound of each nutrient must be considered when developing least-cost rations for maximum efficiency. Energy and protein nutrients are the major ones considered when making nutrient cost comparisons.

Steps in Balancing a Ration

Step 1 - Identify the kind, age, weight, and function of the animal(s).

Step 2 - Consult a table of nutrient requirements to determine the nutrient needs of the animal(s). These requirements are called feeding standards. Feeding standards are based on average requirements and might not meet the needs under specific feeding conditions.

Step 3 - Choose the feeds to be used in the ration and consult a feed composition table to determine the nutrient content of the selected feeds.

Step 4 - Calculate the amounts of each feed to use in the ration. Several methods are available. The Pearson Square or algebraic equation methods can be used to balance a ration using two or more feeds. (See Figure 9.1.) Computer programs can also help balance rations.

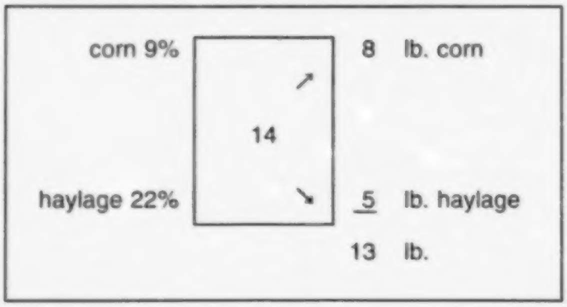
Step 5 - Check the ration formulated against the needs of the animal(s). Be sure it meets the requirements for minerals and vitamins. Check the cost of the nutrients in the ration to determine if this is the most economical ration that is practical to feed.

Eight Essentials of a Balanced Ration

A good ration includes certain basics:

1. Nutrients in the ration should be balanced. Faster gains, less expense, and more profits are the benefits of feeding balanced rations.
2. The ration should contain a variety of feeds. This variety generally increases the palatability of the ration and make it easier to balance the nutrients.
3. The ration should be fresh and appealing. Livestock consume more of a fresh ration, thus increasing productivity.
4. A palatable (good tasting) ration is more readily consumed, adding to the producer's gains.
5. Bulk in the ration is usually more desirable. Feeds such as ground oats, beet pulp, etc., add bulk.
6. A ration should be slightly laxative because a laxative ration usually improves efficiency.
7. The ration should be economical.
8. Since digestive systems of animals are different among species, the ration should be suited to the animal. Cattle and sheep can consume large quantities of roughage, while poultry and swine rations must consist largely of concentrates.

FIGURE 9.1 - Pearson Square Computation



Summary

There are basic nutritional needs for different classes of livestock. For growth to occur, every one of the five nutrients (protein, energy, minerals, vitamins, and water) must be present in sufficient quantity.

Credits

Cullison, Arthur Edison. *Feeds and Feeding*. Reston, VA: Reston Publishing Co., 1979.

Ensminger, M. E., and Olentine, C. G., Jr. *Feeds and Nutrition*. Clovis, CA: The Ensminger Publishing Company, 1978.

Gillespie, James R. *Animal Nutrition and Feeding*. Albany, NY: Delmar Publishers, Incorporated, 1987.

Lesson 1:
Importance of Genetics in Agriculture

There are many careers associated with animal genetics. This occupational area is expanding every day because of new methods of genetic advancement such as: cloning, AI (artificial insemination), and embryo transfer. Employment in livestock genetics is divided into two areas: (1) supplies and services and (2) production.

Occupations Associated with Livestock Genetics

The supplies and services area usually requires a rigorous academic background and a strong agricultural background. The production area requires a very strong agricultural background, a good academic background, and extensive work experience to gain employment. These criteria also apply to independent producers.

Some occupations in the production area are: farm manager, animal breeder, dairy herd owner, horse rancher, cattle rancher, sheep rancher, swine producer, poultry producer, and specialty animal breeder.

In the supplies and services area, some occupations are: veterinarian, artificial breeding technician, veterinarian assistant, ova transplant specialist, breeding services representative, breed association employee, field sales representative for animal breeding products, artificial inseminator, cloning technician, and embryo technician. This is only a partial list of occupations.

Economic Importance of Genetics

How can genetics influence the economic outcomes of livestock? Consider the case of a sow that produces 10 pigs per litter and another sow that produces eight pigs per litter. A good farm manager would pick the sow that produces 10 pigs per litter, because that sow will produce more income than the other sow.

How does genetics play a part in this? It is a fact that litter size is a 15% heritability trait. That means that the litter size of a sow is determined by 15% inheritance from parents and 85% from environment. So the boar used has an influence on how many pigs are produced, and this influences the amount of income produced from that sow.

Another example is the birth weight in beef cattle. Birth weight is a 40% heritability trait. That means that birth weight is determined from 40% inheritance and the other 60% is influenced by environment. How does the environment influence the birth weight in beef cattle? Consider if one cow has winter shelter during her pregnancy and another cow does not. Which cow will have a higher birth weight? A good farm manager would assume that the cow that had shelter would have a larger calf because she used fewer calories on body maintenance and utilized extra calories for her calf.

Heritability traits are broken down into three categories. The first category is called management traits. These traits are influenced by management techniques and decisions. For example, swine litter size at weaning is a management trait, because care of sows and facilities are management decisions.

The second category is known as physical traits. These traits are influenced by actual physical attributes of that animal. For example, the udder support in dairy cattle is a physical attribute of that specific animal.

The last category is production traits. These traits directly influence the quality of products and income received from the animal. For example, rate of gain is a production trait because it directly influences the income received from that animal. The less time a steer is in the feedlot, the less feed and money that is spent on that animal.

TABLE 1.1 - Heritability Traits in Beef Cattle

Trait	Type	Inheritance to offspring (%)	Environmental influence (%)
Calving interval or fertility	Management	10	90
Birth weight	Management	40	60
Cow maternal ability	Management	40	60
Weaning weight	Production	30	70
Carcass grade	Production	40	60
Efficiency of gain	Production	40	60
Fat thickness	Production	45	55
Pasture gain	Production	30	70
Feedlot gain	Production	45	55
Final feedlot weight	Production	60	40
Tenderness	Production	60	40
Rib eye area	Production	70	30
Conformation score (at weaning)	Physical	25	75
Cancer eye susceptibility	Physical	30	70

TABLE 1.2 - Heritability Traits in Dairy Cattle

Trait	Type	Inheritance to offspring (%)	Environmental influence (%)
Milking speed	Production	25	75
Milk production	Production	25	75
Feed lot gain	Production	45	55
Percent of soluble nitrogen-free extracts	Production	50	50
Percent protein in milk	Production	50	50
Percent fat in milk	Production	50	50
Legs and feet	Physical	15	85
Udder support	Physical	20	80
Stature	Physical	40	60

TABLE 1.2 - Heritability Traits in Dairy Cattle

Trait	Type	Inheritance to offspring (%)	Environmental influence (%)
Fertility	Management	5	95
Birth weight	Management	40	60
Temperament	Management	40	60

TABLE 1.3 - Heritability Traits in Sheep

Trait	Type	Inheritance to offspring (%)	Environmental influence (%)
Multiple births	Management	15	85
Birth weight	Management	30	70
Type score for weanling	Physical	10	90
Wrinkles and skin folds	Physical	40	60
Yearling type score	Physical	40	60
Face covering	Physical	56	44
Carcass grade	Production	12	88
Carcass weight/day of age	Production	22	78
Carcass length	Production	31	69
Finish or condition at weaning	Production	17	83
60-day weight	Production	10	90
100-day weight	Production	30	70
Rate of gain	Production	30	70
Fleece grade	Production	35	65
Fat thickness over loin eye	Production	35	65
Staple length for weanling	Production	39	61
Fleece weight and grease weight	Production	38	62
Staple length for yearlings	Production	47	53
Loin eye area	Production	53	47

TABLE 1.4 - Heritability Traits in Swine

Trait	Type	Inheritance to offspring (%)	Environmental influence (%)
Birth weight	Management	5	95
Litter size at birth	Management	15	85
Litter size at weaning	Management	12	88
Litter weight at weaning	Production	15	85
Efficiency of feed utilization	Production	30	70
Days to 230 lbs.	Production	35	65
Back-fat thickness	Production	40	60
Daily rate of gain from weaning to market	Production	40	60
Percent lean cuts to offspring	Production	50	50
Muscle in loin area	Production	50	50
Predicted percent lean	Production	58	42
Carcass length	Production	60	40
Conformation	Physical	29	71

Genetic Selection

Traditionally, animals were selected based on their physical traits. Since records were not available, animals were chosen by the type of individual, their pedigree, and by show-ring winnings. Now, there are an abundance of production, physical, and management records kept on animals, especially purebred and show animals. These records introduced production testing, which is the latest genetic selection method.

Today, animal selection is based on three types of testing: performance, progeny, and production. Performance testing is the practice of evaluating and selecting animals based on their merit or performance. For example, performance testing on a bull would include its 365-day weight.

Progeny testing is the practice of selecting animals based on the merit of their progeny (offspring). This testing was used more in the past, but today, more extensive records are kept. Progeny testing is used in selection of animals based on the performance of their offspring.

Production testing involves keeping accurate performance and progeny records, rather than casual observations. Production testing is the systematic measurement of differences in economically important traits and the *recording* of these differences for use in selection. Production testing is also used to compare animals that are handled alike (same lot, same feed, same amount of feed) to determine the better-performing animal. This method is not reliable in comparing different herds--just individuals. Finally, production testing is also used as a selection tool to increase the rate of genetic improvement in individual herds.

Summary

It is vital for livestock producers and others in livestock-related occupations to understand economic traits associated with genetics and to select livestock based on genetic improvement.

Credits

Careers Unit for Ag Science I Core Curriculum (Teacher's guide). University of Missouri-Columbia: Instructional Materials Laboratory, 1988.

Ensminger, M. E. *The Stockman's Handbook*. 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Lesson 2:
Basic Building Blocks of Genetics

Cells are the basic, microscopic building units of all living things, and they reproduce through division. Cells are the beginning and the basis for every function within the body.

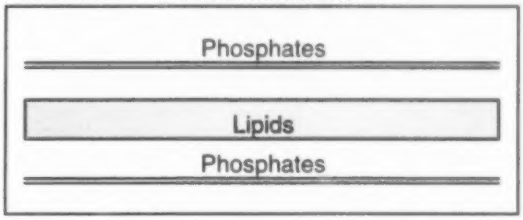
How Cells Function

Parts of the cell - Cells are complex systems that consist of several smaller structures within the cell. These smaller, membrane-bound structures are called organelles ("little organs"). The function of the cell depends on the organelles present in the cell. Therefore, the organelles determine the function of the cell.

The plasma membrane is the thin layer surrounding the cell. This very active part of the cell determines which molecules can enter or exit the cell.

The plasma membrane consists of two layers of molecules called phospholipids. Phospholipids are made up of a lipid and a phosphate group. Lipids are not soluble in water, but phosphates are. Phosphates sandwich the lipid layer in the plasma membrane. This allows certain molecules to enter and exit the cell, but not lipids. (See Figure 2.1.)

FIGURE 2.1 - Plasma Membrane



The spherical organelle that is located near the center of the cell is the cell nucleus. It controls the production of proteins in the cell. The nucleus also holds important information about the cell in DNA. The parts of the cell nucleus include the nuclear membrane, chromatin, chromosomes, and nucleolus.

The nuclear membrane separates the content of the nucleus from the rest of the cell. This membrane also allows substances to exit and enter the nucleus. The chromatin holds the necessary hereditary information about the cell so it can reproduce similar cells. The nucleolus is the darker part of the chromatin, which is involved in the production of ribosomes.

Cytoplasm is the gel-like substance that surrounds and suspends a cell's organelles.

Mitochondria are organelles that contain enzymes that release energy from food molecules during cellular respiration. The number of mitochondria in a cell depends on the function of the cell. An active muscle cell, such one found in the heart, contains more mitochondria because it requires more energy.

Ribosomes are tiny, round organelles that are involved in the protein synthesis. A majority of ribosomes attach themselves to long strands of membrane called endoplasmic reticulum. These attached ribosomes synthesize proteins that are released for use by other cells in the body. The ribosomes that float within the cytoplasm synthesize proteins used by the cell itself.

The two types of endoplasmic reticulum are smooth and rough. Rough endoplasmic reticulum contains ribosomes necessary for protein synthesis. Smooth endoplasmic reticulum does not contain ribosomes, so it is not involved with protein synthesis, but it does add structure to the cell.

Golgi bodies are flat, membrane-bound sacs that prepare proteins for secretion from the cell. Vesicles are tiny pieces of membrane pinched off the Golgi body that actually carry proteins to the plasma membrane. Golgi bodies catch proteins floating in the cytoplasm, and then vesicles carry these proteins to the plasma membrane.

Within the cytoplasm, there are membrane-bound, fluid-filled spaces called vacuoles. These vacuoles are usually filled with water and have their own membrane to separate them from the rest of the cell. Vacuoles provide shape and structure to the cell.

Proteins are actually digested by lysosomes. These organelles contain enzymes that break down proteins and recycle amino acids to make new proteins.

Cytoskeleton is the tiny internal support system found in cells. It is made up of many tiny protein strands called microtubules. The cytoskeleton resembles a fish net. Each strand in the net would be called a microtubule. The cytoskeleton provides shape and structure, but it also limits the movement of organelles within the cell.

The centriole is a cylindrical organelle that contains its own microtubules that lie near the cell nucleus. Most animal cells contain two centrioles. These pairs of centrioles are composed of nine sets of microtubules and play an important role in cell division.

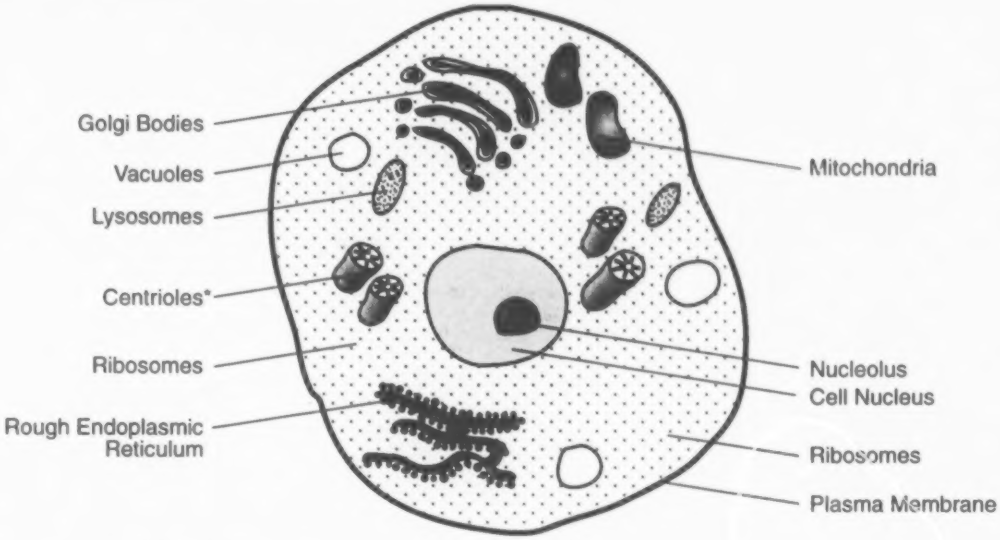
Types of cells - The two types of cells are eukaryotes and prokaryotes. Eukaryotes are cells that contain a membrane-bound cell nucleus. The eukaryote chromatin is held within a well-defined nucleus.

Not all organisms contain a nucleus. Prokaryotes are cells that do not contain a membrane-bound nucleus. The chromatin in prokaryotes is stretched out within the cytoplasm and not held within a nucleus. Bacteria are considered prokaryote because of the lack of a membrane-bound nucleus and other organelles. Prokaryotes lack organelles such as mitochondria and Golgi bodies.

Functions of cells - All active cells have four functions. The first function, nutrition, is the ability to manufacture their own food or obtain food from other environmental sources. The second function is cellular respiration, the process of changing the energy in food molecules into a usable form of energy. The third function, absorption, is the process of absorbing water, minerals, and other necessary elements from environmental sources. Biosynthesis is the fourth function. Biosynthesis is the process of synthesizing complex compounds from simpler compounds. A good example of biosynthesis is changing proteins into amino acids.

Differences between animal and plant cells - There are several differences between animal and plant cells. The first difference is the cell wall. Plant cells have a cell wall that surrounds the plasma membrane, while animal cells do not. When a cell is first formed, a primary cell wall surrounds the cell, and as the cell matures a secondary cell wall is formed inside the plasma membrane. The cell

FIGURE 2.2 - Animal Cell Components



*Found only in animal cells

wall does not determine what enters or exits the cell, but adds strength to the cell. Even when the plant cell dies, the cell wall remains (for example, as bark on trees).

The second difference is chloroplasts. In plant cells, chloroplasts provide green coloring. The third difference is chlorophyll. Plant chlorophyll uses sunlight to manufacture food for the plant.

Plastids are the fourth difference. In plants, plastids are organelles capable of storing food for the cell. Animal cells use food just for the current needs of the cell; therefore, no storage of food is necessary.

The fifth difference is chromoplasts. Plant cells contain chromoplasts, which provide color for fruits and flowers. Chromoplasts make tomatoes red, roses yellow, and lettuce green.

DNA's Effect on Genetics in Livestock

Definitions of DNA and RNA - DNA (**d**eoxyribo**n**ucleic **a**cid) is a nucleic acid molecule that controls the production of proteins. DNA is similar to a library in that it stores vital information about the cell. The DNA instructions are used repeatedly in cell division and protein synthesis. In eukaryotes, DNA is stored in the chromosomes in the nucleus. In prokaryotes, DNA is stored in circular strands that are located in the cytoplasm.

Structure of DNA - DNA is composed of nucleotides. Nucleotides are made up of three parts: a phosphate group, a nitrogen base, and a five-carbon sugar called deoxyribose.

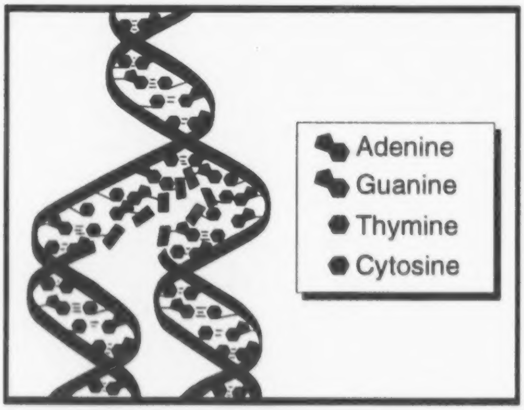


TABLE 2.1 - DNA strand
S ------ GC ------ S
P P
S ------ CG ------ S
P P
S ------ AT ------ S
P P
S ------ TA ------ S
P P
S ------ GC ------ S
P P
S ------ CG ------ S
P P
S ------ AT ------ S
P P
S ------ TA ------ S
P-Phosphate S-Deoxyribose sugar Nitrogen bases: A-Adenine T-Thymine G-Guanine C-Cytosine

TABLE 2.2 - RNA strand
R--G
P
R--A
P
R--U
P
R--C
P
R--G
P
R--A
P
R--U
P
R--C
R-Ribose sugar P-Phosphate Nitrogen bases: G-Guanine A-Adenine U-Uracil C-Cytosine

A DNA nucleotide has one of four nitrogen bases. The four nitrogen bases are adenine, guanine, thymine, and cytosine. The "base pairing rule for DNA" is that adenine is always paired with thymine and guanine is always paired with cytosine. These nitrogen bases must be paired in this order to form a DNA strand. Then, these nitrogen pairs are attached to a phosphate and a deoxyribose.

The nitrogen-based pairs are sandwiched between a phosphate and a deoxyribose to form a DNA strand. These constructed DNA strands are then twisted into a spiral, like a spiral staircase. This spiral twist is called a double helix. Table 2.1 shows the structure of a DNA strand. A single DNA molecule can be millions of base pairs long. The order in which the nitrogen bases are arranged determines the function of the cell and the DNA's ability to run.

Formation of amino acids - Codons are three nitrogen bases attached together to form an amino acid. Any one of the triplets can form an amino acid. It does not take all the triplets to form an amino acid. In Table 2.3 is a list of codons that make up amino acids. Several codons represent the same amino acid. Since they have the same meaning, the redundant codons are like synonyms of words.

RNA's Effect on Genetics in Livestock

RNA (ribonucleic acid) is a nucleic acid that is shorter in length than DNA. RNA carries messages from DNA, transforms amino acids, and forms ribosome structures.

Structure of RNA - RNA nucleotides contain a phosphate group, a ribose sugar, and a nitrogen base. This is also determined by chemical analysis. RNA is made up of a ribose sugar instead of a deoxyribose found in DNA. Like DNA, RNA contains four nitrogen bases, but RNA contains uracil, which replaces thymine in DNA. Uracil acts in the same way as thymine. RNA usually has only one strand, instead of two like DNA. See Table 2.2.

Functions of RNA - There are three types of RNA--messenger RNA (m-RNA), transfer RNA (t-RNA), and ribosomal RNA (r-RNA). In eukaryotes, DNA never leaves the nucleus, so m-RNA (messenger RNA) carry messages from DNA to ribosomes. Ribosomes synthesize necessary proteins, but DNA decides which proteins need to be synthesized, and the m-RNA carry that assignment to ribosomes.

Transcription is the process of copying the DNA code to RNA strands. Transcription carries the necessary information to the ribosomes to form proteins. Getting all the necessary amino acids and lining them up in the right order to build a specific protein is the job of transfer RNA or (t-RNA). The cytoplasm contains all the amino acids necessary for building a specific protein. The t-RNA then gathers the proper amino acids in proper alignment and brings them to the ribosomes.

Translation is the process of assembling chains of amino acids according to the directions carried by the m-RNA and then translating the message into a particular protein. This assembly of t-RNA and m-RNA is done in the ribosome. The final function of RNA is to form ribosomes. The formation of the structure of ribosomes is done by r-RNA (ribosomal RNA). The r-RNA is made in the nucleolus of the cell.

Differences between DNA and RNA - As mentioned previously, RNA nucleotides contain a sugar, ribose, instead of the deoxyribose found in DNA. RNA contains a nitrogen base called uracil, which takes the place of thymine found in DNA. Uracil still forms a complementary pair with adenine, as in DNA. The DNA strand consists of two strands of a phosphate and a deoxyribose attached to a nitrogen base pair, but in an RNA strand there is only one strand of a phosphate and ribose attached to a nitrogen base pair. Remember, a DNA strand forms a double helix, but an RNA strand does not.

Summary

Cells, DNA and RNA are the starting points for all genetic occurrences in livestock. That is why it is so important to comprehend the functions and structures in cells.

Credits

McLaren, J.; L. Rotundo. *Heath Biology*. Lexington, MA: D. C. Heath and Company, 1985.

Oram, Raymond F. *Biology Living Systems*. 6th ed. Columbus, OH: Merrill Publishing Company, 1989.

TABLE 2.3 - The 20 Most Common Amino Acids

Essential amino acids	Non-essential amino acids
Arginine (TCT, TCC, GCA, GCG, GCT, GCC)	Alanine (CGA, CGG, CGT, CGC)
Histidine (GTA, GTG)	Asparagine (TTA, TTG)
Isoleucine (TAA, TAG, TAT)	Aspartic acid (CTA, CTG)
Leucine (AAT, AAC, GAA, GAG, GAT, GAC)	Cysteine (ACA, ACG)
Lysine (TTT, TTC)	Glutamic acid (CTT, CTC)
Methionine (TAC)	Glutamine (GTT, GTC)
Phenylalanine (AAA, AAG)	Glycine (CCA, CCG, CCT, CCC)
Threonine (TGA, TGG, TGT, TGC)	Proline (GGA, GGG, GGT, GGC)
Tryptophan (ACC)	Serine (AGA, AGG, AGT, AGC, TCA, TCG)
Valine (CAA, CAG, CAT)	Tyrosine (ATA, ATG)

Lesson 3:
Animal Cell Division

Each animal begins as one cell. This cell divides to make two cells. The cell continues to divide, and groups of cells form specialized tissues and organs in the animal's body. An animal's genetic traits are inherited from their parents through the transfer of genes through cell division.

Genes and Chromosomes

Rod-shaped chromosomes within the cell nucleus act as carriers for genes, the basic units of heredity. Composed of DNA, each gene organizes itself on the chromosome in a position called a locus. An offspring receives one-half of its total genetic material from each parent. Therefore, the number of chromosomes in each body cell is said to be 2n (diploid). Chromosomes are diploid in number (exist in pairs) in all body cells, except sperm and egg cells. One chromosome of each pair comes from the father and one comes from the mother. The haploid number is "n" and represents the chromosome number found in the sex cells contributed by one parent:

1n (male) + 1n (female) = 2n new offspring

Chromosomes in Common Livestock

Each species has a designated number of chromosomes. A human being has 46 chromosomes; a donkey has 64; and a bengal tiger has 38 in the 2n state. In diploid cells, chromosomes are paired. Each matched pair tends to resemble the other in size and shape, and they both carry genes affecting the same traits. Chromosomes in this relationship are said to be homologous (meaning alike or equal). Two genes located on the same locus on each homologue constitute a gene pair. One homologue contributes information from the female parent, while the other originates from the male parent.

Credit: ***Agriscience 332: Animal Science (Student Reference).*** Courtesy of Instructional Materials Service, Texas A & M University, College Station, Texas. Appreciation is extended to IMS for use of portions of the *Agriscience 332: Animal Science* instructional materials.

TABLE 3.1 - Characteristic Numbers of Chromosomes in Selected Animals

Animal	**Chromosome Number (2n)**
Horse	64
Mule	63
Swine	38
Sheep	54
Cattle	60
Human	46
Dog	78
Domestic cat	38
Chicken	78

Chromosomes contain millions of genes. It is because of the large number of genes and possible combinations of genes that very few animals are exactly alike.

Cell Division by Mitosis

Through cell division, cells are able to increase in number. The two types of cell division are mitosis and meiosis. In mitosis, each cell divides and forms two "daughter cells," both with a complete set of chromosomes identical to those in the parent cell.

Animal growth is caused by cell division. As cells divide, the animal increases in size. A single cell divides into two cells; these two cells divide into four cells, and so on.

Mitosis is the exact duplication of cells in the body. As shown in Figure 3.1, mitosis involves several different phases.

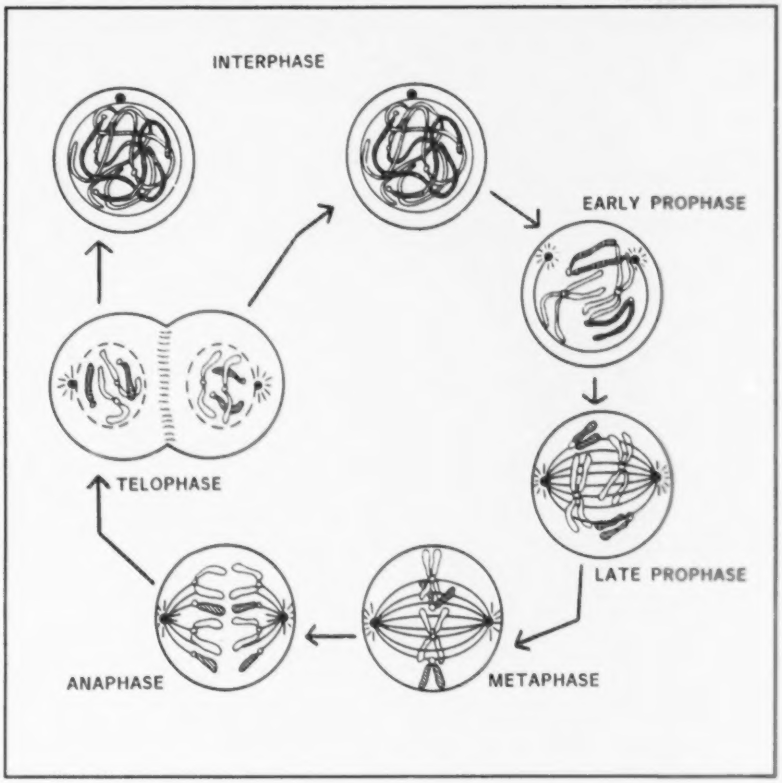
Prophase - The process of mitosis begins in prophase.

1. Early prophase: Chromosomes shorten, thicken, and appear as double strands of sister chromatids connected by a centromere.
2. Mid-prophase: The nuclear membrane disappears.
3. Late prophase: The centromere becomes attached to the newly formed spindle fibers.

Metaphase - The centrioles migrate to the poles, and the chromatids arrange themselves along the equator of the spindle fibers.

FIGURE 3.1 - Mitosis Phases

Credit: *Agriscience 332: Animal Science*



Anaphase - Each centromere separates into two centromeres, each with a chromatid. The centromere then moves toward the mitotic center, dragging its chromatid with it. The chromatids become the new chromosomes and are pulled to the centrioles at opposite ends of the cell.

Telophase - The nucleus reforms, and the nuclear membrane reappears around each mitotic center, resulting in two nuclei. The chromosomes grow longer and disperse into a network of fine threads. This phase of mitosis is completed when the cytoplasm. This division forms two new cells with the same chromosome makeup as the original mother cell.

Interphase - This is the resting period between the telophase of one cell division and the prophase of the next division.

Cell Division by Meiosis

Inheritance is determined by meiosis and in fertilization. In meiosis, the chromosome number of gametes or sex cells is reduced by one-half from the diploid (2n) number to the haploid (1n) number. When the egg and sperm unite in fertilization, the diploid number of chromosomes are restored to normal. This ensures that the progeny receives one-half of its chromosomes from each parent.

The stages of meiosis are organized into two sequential divisions called Meiosis I and Meiosis II. (See Figure 3.2.) Meiosis I begins with interphase, in which DNA replicates or reproduces itself so that by the beginning of Meiosis II, each chromosome will have two "sister chromatids" joined by a centromere. The stage after interphase is Prophase I, in which the chromatin or genetic material containing DNA appear as thin threads. Prophase of the first meiotic division is subdivided into five stages (Table 3.2).

TABLE 3.2 - Stages in Prophase of Meiosis I

Stage	Features
1. Leptotene	Chromosomes elongate, but appear single.
2. Zygotene	Homologous chromosomes pair, forming n bivalents.
3. Pachytene	Bivalents shorten.
4. Diplotene	Homologues pull slightly apart, revealing separate chromatids.
5. Diakinesis	Homologous centromeres move apart; chromatids shorten more.

In the second stage of prophase, homologous chromosomes come together side by side in pairs called synapsis. The chromosomes then contract and thicken; each one splits lengthwise (except at the centromere). These synapsed pairs, known as tetrads, contain four strands called chromatids (two strands from the maternal parent and two from the paternal parent).

When the homologues are paired in this fashion, an event known as crossing over can occur. This involves the exchange of one portion of one chromosome for a corresponding portion of its homologue. This is one way that variation becomes introduced in the inheritance.

In metaphase, the next stage of Meiosis I, the nuclear membrane disappears and the homologues move toward the equatorial or mid-line of the cell. The centromere of each pair of homologues also becomes attached to the spindle--one above and the other below the equator.

During anaphase, homologues separate and are pulled to opposite poles of the cell by the spindle fibers. Thus separated, each homologue consists of two chromatids. Reduction division occurs in anaphase when the number of chromosomes moving toward each pole is only one-half the number of chromosomes in a 2n cell.

The first meiotic division ends with telophase. Here, the separated chromosomes disperse as the spindle fibers disappear and nuclear membranes form. The cytoplasm divides to create two "daughter cells," each with one-half he chromosomal material of the parent cell. There is a "resting stage" known as interkinesis that lies between Meiosis I and Meiosis II. Unlike interphase, no replication occurs at this time.

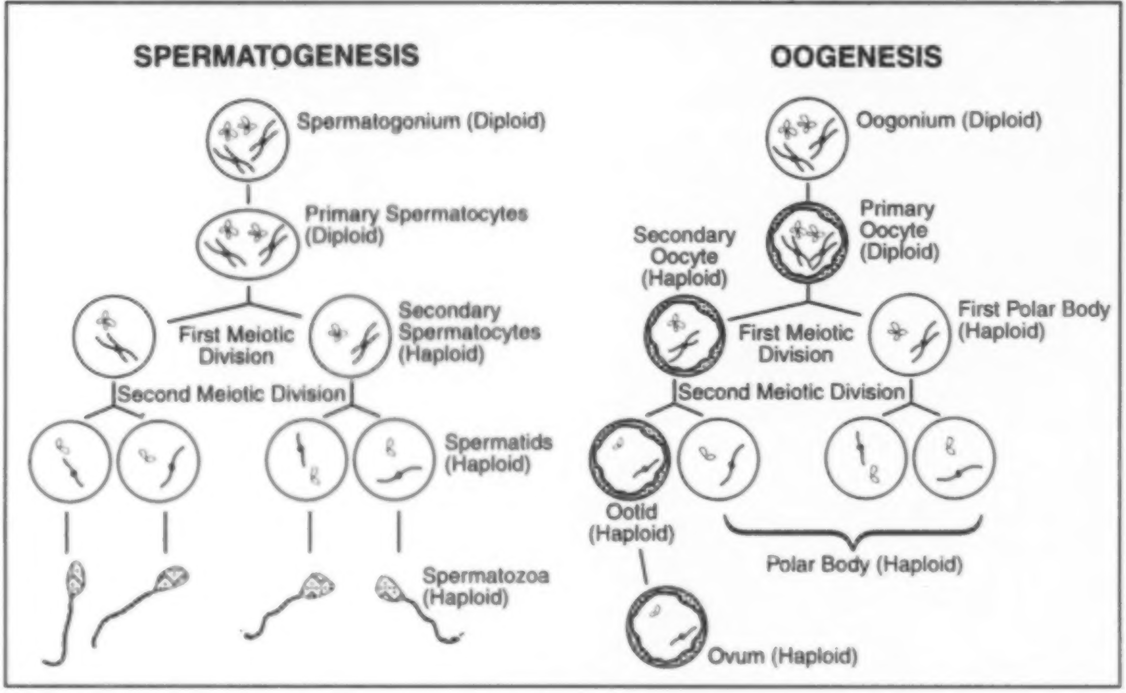
Meiosis II begins with Prophase II. During this stage, the genetic material condenses once more to form visible chromosomes. Recall that each chromosome is now composed of only two chromatids. Spindle fibers form as the nuclear membranes dissolve.

Chromosomes line up on the equatorial plane in Metaphase II. The centromere of the sister chromatids separate as the spindle fibers act to pull the new, individual chromatids to the opposing poles of each cell to complete Anaphase II.

Meiosis II ends in Telophase II where the chromosomes disperse, the spindle fibers are eliminated, and nuclear envelopes reform. The

FIGURE 3.2 - Meiosis Phases

Credit: *Agriscience 332: Animal Science*


SPERMATOGENESIS
Spermatogonium (Diploid)
Primary Spermatocytes (Diploid)
First Meiotic Division
Secondary Spermatocytes (Haploid)
Second Meiotic Division
Spermatids (Haploid)
Spermatozoa (Haploid)
OOGENESIS
Oogonium (Diploid)
Secondary Oocyte (Haploid)
Primary Oocyte (Diploid)
First Meiotic Division
First Polar Body (Haploid)
Second Meiotic Division
Ootid (Haploid)
Polar Body (Haploid)
Ovum (Haploid)

cytoplasm divides again. The end product results in four individual sex cells that contain a haploid number of genetic material in each. The process is more simply described in consecutive steps:

Step 1: Chromosomes begin to appear as thread-like strands. Each chromosome has already replicated during interphase.
Step 2: Each doubled chromosome lines up with another doubled chromosome of equal length.
Step 3: Each group of four chromosomes line up along the center of the cell. Fibers formed in the cell move the chromosomes to their correct positions.
Step 4: The groups of four chromosomes now separate. The original and its replication remain together. Those pairs are pulled toward one end of the cell. The other pair is pulled to the opposite end.
Step 5: The cell splits in half, forming two new cells. So far, the chromosome number of each new cell is the same as the number in the original cell.
Step 6: Once again, the chromosome pairs line up along the center of the cell. This time they line up in a direction different from Step 3.
Step 7: Chromosome pairs pull apart. An original moves toward one end of the cell, while a copy moves in the opposite direction.
Step 8: Each new cell now separates into two. A nuclear membrane begins to form around the chromosomes. Note that in Step 1 there was one cell containing four chromosomes before each replicated. Now there are four new sex cells, each with half the number of chromosomes that was present in the original cell.

Meiosis produces both sperm and egg cells. In the male, spermatogenesis produces four sperm cells from each cell. Each of these receives one-half the number of chromosomes of the original cell. In the female process of oogenesis, however, only one egg is produced; it has one-half of the chromosomes present in the original cell. The other three cells, called polar bodies, die in the process of egg formation.

Comparing mitosis and meiosis - Mitosis and meiosis are both forms of cell division, although they are not used for the same type of cells. Meiosis involves two separate divisions, while mitosis involves only one. For other differences, see Figure 3.3.

Summary

An animal's body is made up of millions of cells. Animals grow by cell division. The cell nucleus contains chromosomes, which are found in pairs. One chromosome of the pair comes from the father and one comes from the mother. Ordinary cell division is called mitosis, and each cell is exactly like the old cell. Reproductive cells are called gametes, which divide by meiosis.

Credits

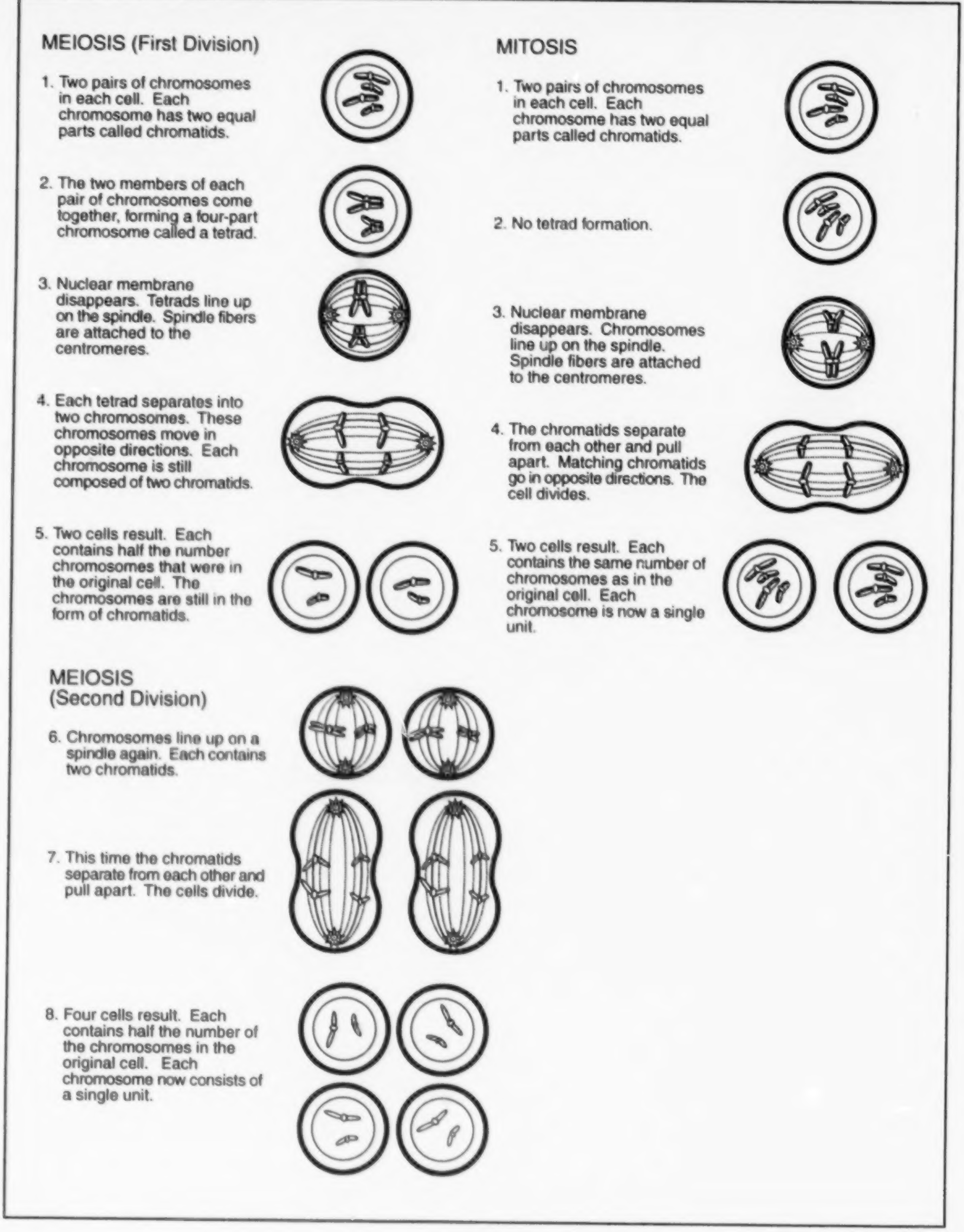
Agriscience 332: Animal Science (Student Reference). Texas A & M University: Instructional Materials Service, 1989.

Gillespie, James R. *Modern Livestock and Poultry Production.* 4th ed. Albany, NY: Delmar Publishers, Inc., 1992.

Oram, Raymond F. *Biology Living Systems.* Columbus, OH: Merrill Publishing Company, 1989.

FIGURE 3.3 - Meiosis vs. Mitosis

Credit: *Agriscience 332: Animal Science*



MEIOSIS (First Division)

1. Two pairs of chromosomes in each cell. Each chromosome has two equal parts called chromatids.
2. The two members of each pair of chromosomes come together, forming a four-part chromosome called a tetrad.
3. Nuclear membrane disappears. Tetrads line up on the spindle. Spindle fibers are attached to the centromeres.
4. Each tetrad separates into two chromosomes. These chromosomes move in opposite directions. Each chromosome is still composed of two chromatids.
5. Two cells result. Each contains half the number chromosomes that were in the original cell. The chromosomes are still in the form of chromatids.

MEIOSIS
(Second Division)

6. Chromosomes line up on a spindle again. Each contains two chromatids.
7. This time the chromatids separate from each other and pull apart. The cells divide.
8. Four cells result. Each contains half the number of the chromosomes in the original cell. Each chromosome now consists of a single unit.

MITOSIS

1. Two pairs of chromosomes in each cell. Each chromosome has two equal parts called chromatids.
2. No tetrad formation.
3. Nuclear membrane disappears. Chromosomes line up on the spindle. Spindle fibers are attached to the centromeres.
4. The chromatids separate from each other and pull apart. Matching chromatids go in opposite directions. The cell divides.
5. Two cells result. Each contains the same number of chromosomes as in the original cell. Each chromosome is now a single unit.

Lesson 4:
Basic Principles of Genetics

Each animal is made up of many different characteristics. Its color, size, being horned or polled, and carcass traits are only a few of the characteristics that are inherited from its parents. Genes control these traits and are the basic units of heredity. Even the word "genetics" originates from the word "gene."

Roles of Genes and Alleles

Genes and alleles - Chromosomes within the cell nucleus act as carriers for genes. Composed of DNA, each gene organizes itself on the chromosome in a position called a locus (plural, loci). An offspring receives one-half of its total genetic material from each parent. Therefore, the number of chromosomes in each body cell of an organism is 2n or diploid. The haploid number is "n" and represents the chromosome number found in sex cells contributed by one parent.

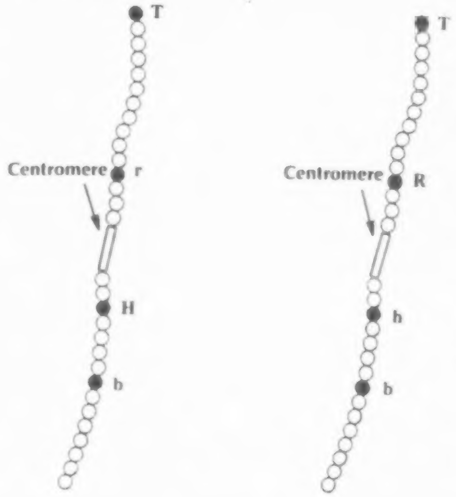
In diploid pairs, the chromosomes are paired. Each matched pair resembles each other in size and shape, and they both carry genes affecting the same traits. Chromosomes in this relationship are homologous. Two genes, which are located on the same loci on each homologue, form a gene pair. One homologue contributes information from the female parent, while the other originates from the male parent.

Each gene pair has two alleles. These two alleles interact to influence the character traits of an organism. A species may contain many different forms (multiple alleles) of the same gene. For example, a gene pair that codes for flower color may have several possible combinations. The allele "R" might represent an allele that codes for red, while "r" might code for blue flowers, and "y" might code for yellow. (See Figure 4.1.)

Additive and nonadditive gene action - An additive type of gene action refers to the situation when several individual genes each add to the phenotypic expression of a trait. Performance traits, with high heritability, such as rate of gain, feed efficiency, lactation, and egg laying are often affected by additive gene action. These types of traits might be affected by many pairs of genes.

FIGURE 4.1 - Homologous Chromosome Pair Diagram

Credit: *Agriscience 332H: Animal Science (Student Reference).* Courtesy of Instructional Materials Service, Texas A & M University, College Station, Texas. Appreciation is extended to IMS for use of portions of the *Agriscience 332H: Animal Science* instructional materials.



When additive gene action is involved, superiority for a trait depends on the number of desirable genes an individual possesses. Therefore, selection for additive gene action should be based primarily on the individual's merit.

TABLE 4.1 - Traits Controlled by a Single Pair of Genes

Dominant	Recessive
Black-colored Holstein	Red-colored Holstein
Polled cattle	Horned cattle
White-wooled sheep	Black-wooled sheep
Mule-footed swine	Normal-footed swine
Black-colored Angus	Red-colored Angus
White-faced Herefords	Self-faced Angus
Black-colored horse	Chestnut horse
Dutch-belt pattern	No belting pattern

Nonadditive genes control traits by the way gene pairs act in different combinations with one another. When combinations of gene pairs give good effects, the offspring will be better than either of its parents. This condition, called overdominance, exists when the heterozygote is phenotypically superior to either of the homozygous parents. This is often called heterosis or hybrid vigor.

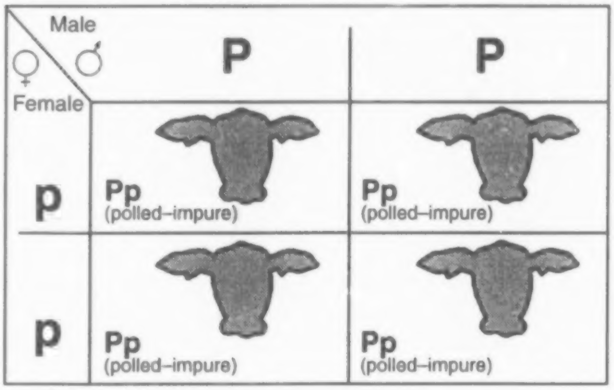
Genotypes and Phenotypes

The genotype of an animal refers to the actual configuration of genes in the animal's cells. The phenotype refers to visible differences in the physical makeup of animals (color, weight, body structure, horned or polled, etc.). This makeup can be observed and is the result of the animal's genotype. Therefore, these phenotypic characteristics of animals, called traits, are controlled a pair of genes or several pairs of genes. Although the development of all traits is predetermined by the action of genes, some can be modified because of differences in the environment.

A square or a checkerboard diagram shows the probable results of breeding livestock. Normally, the male genotype is shown at the top, and the female genotype is indicated in the vertical margin. When crossing homozygous dominant parents (PP x PP), all offspring will be homozygous dominant polled individuals. Each of them can only produce a gamete with the dominant for the polled trait. The situation is the same when crossing homozygous recessive parents (pp x pp). All offspring will be horned. When crossing a homozygous dominant parent with a homozygous recessive parent (PP x pp), all offspring would be heterozygous and polled. This cross is illustrated in Figure 4.2.

FIGURE 4.2 - Homozygous Polled (PP) X Homozygous Horned (pp)

Credit: *Agriscience 332H: Animal Science*



When crossing a heterozygous parent with a homozygous dominant parent (Pp x PP), the expected offspring would occur in a 1:1 ratio of homozygous dominant to heterozygous individuals. Phenotypically, all offspring would be polled. If two heterozygous parents are crossed (Pp x Pp), one can expect an offspring genotypic ratio of 3:1 of the phenotypic expression of dominant pooled traits. Genotypically, there is a possibility of one homozygous dominant polled, one homozygous recessive horned, and two heterozygous polled offspring. The horned individual produced from the cross will not carry a gene for the polled trait, although both parents were polled. This cross is shown in Figure 4.3.

To learn if a polled bull is homozygous for the polled trait (PP), the bull can be bred to homozygous recessive horned cows (pp). If he is homozygous for the polled trait, his offspring will all be polled. If this polled bull is mated to at least five horned cows with no resulting horned offspring, it is likely (95 percent probable) that the bull is homozygous for the polled trait. This test can determine whether animals are homozygous or heterozygous for other traits, as well.

FIGURE 4.3 - Heterozygous Polled (Pp) X Heterozygous (Pp)

Credit: *Agriscience 332H: Animal Science*

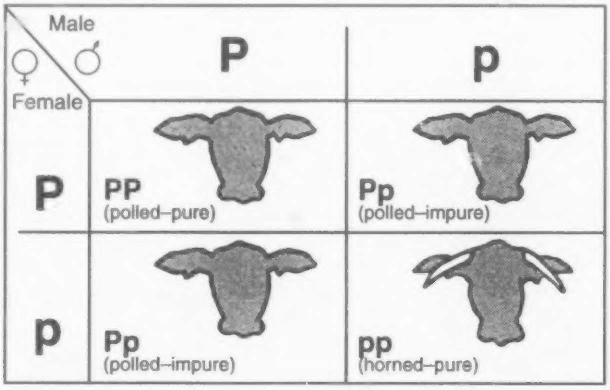
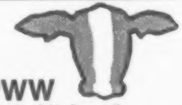
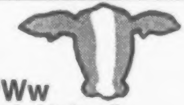
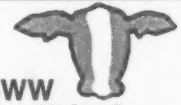
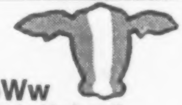
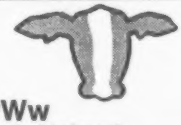
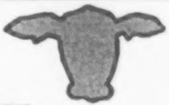
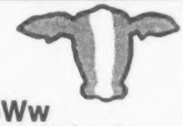
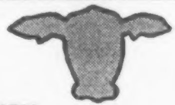
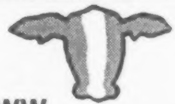
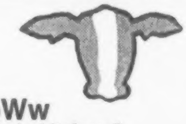
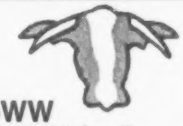
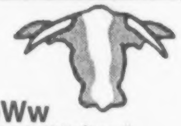
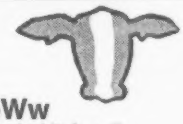
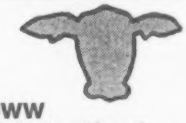
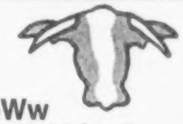
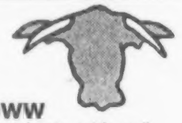


FIGURE 4.4 - Two Pairs of Heterozygous Genes, Each Affecting a Different Trait
Credit: *Agriscience 332H: Animal Science*

Male ♂ / ♀ Female	**PW**	**Pw**	**pW**	**pw**
PW	 **PPWW** (polled whitefaced)	 **PPWw** (polled whitefaced)	 **PpWW** (polled whitefaced)	 **PpWw** (polled whitefaced)
Pw	 **PPWw** (polled whitefaced)	 **PPww** (polled colored faced)	 **PpWw** (polled whitefaced)	 **Ppww** (polled colored faced)
pW	 **PpWW** (polled whitefaced)	 **PpWw** (polled whitefaced)	 **ppWW** (horned whitefaced)	 **ppWw** (horned whitefaced)
pw	 **PpWw** (polled whitefaced)	 **Ppww** (polled colored faced)	 **ppWw** (horned whitefaced)	 **ppww** (horned colored faced)

Only single traits have been discussed up to this point. There are a number of traits to consider in any cross. One can expect a 3:1 ratio based on offspring appearance of a cross between individuals heterozygous for a dominant trait. With two pairs of heterozygous genes, each affecting a different trait, a 9:3:3:1 ration would be expected. (See Figure 4.4.) In the example, two individuals are mated that are heterozygous for the polled and white-faced traits. From this mating, the offspring phenotypically include nine polled white-faced, three polled colored-faced, three horned white-faced, and one horned colored-faced offspring.

Dominant and Recessive Traits

A gene pair is homozygous if both alleles are identical. They may be either dominant or recessive for the particular trait they represent. While homozygous alleles influence the same trait similarly, heterozygous pairs influence the same trait in different ways.

All alleles do not influence traits equally. A dominant allele determines the phenotypic (visible) characteristics, even if only one chromosome of the pair carries that information. Dominant alleles are designated by capital letters, while recessive traits are shown by lower case letters.

For example, "T" represents tallness in cattle and "t" represents shortness. Possible combinations of these two alleles are:

TT - two dominant alleles (tall cattle)
Tt - one dominant allele, one recessive allele (tall cattle)
tt - two recessive alleles (short cattle)

In some situations, incomplete dominance may occur. If "R" encodes red hair in cattle, "W" encodes white hair, and both were equally dominant, neither color would be fully expressed in an RW genotype. The offspring would be roan, a combination of red and white.

Homogenous and Heterogenous Traits

Chromosomes illustrated in Figure 4.1 are homologous because they bear genes affecting the same traits. The circles represent individual genes composed of base sequences. The centromere is a region of the chromosome where spindle fibers become attached. The fibers are important in the movement of chromosomes during meiosis and mitosis (cell divisions).

Contrasting alleles "T" and "t" affect animal height: "T" specifying tallness and "t" specifying shortness. The contrasting alleles "R" and "r" affect resistance to a particular disease: "R" specifying resistance to disease and "r" specifying susceptibility. Contrasting alleles "H" and "h" determine horned of polled conditions: "H" specifying a horned condition and "h" specifying a polled condition. Contrasting alleles "B" and "b" affect hair color. "B" specifies black and "b" specifies red.

The gene pair of alleles "T" and "T," and the gene pair of alleles "b" and "b," are identical alleles. Therefore, this genotype is homozygous for the genes for height and coat color. The gene pair of alleles "R" and "r," and the gene pair of alleles "H" and "h," are contrasting alleles. Thus, this genotype is heterozygous for disease resistance and horn development.

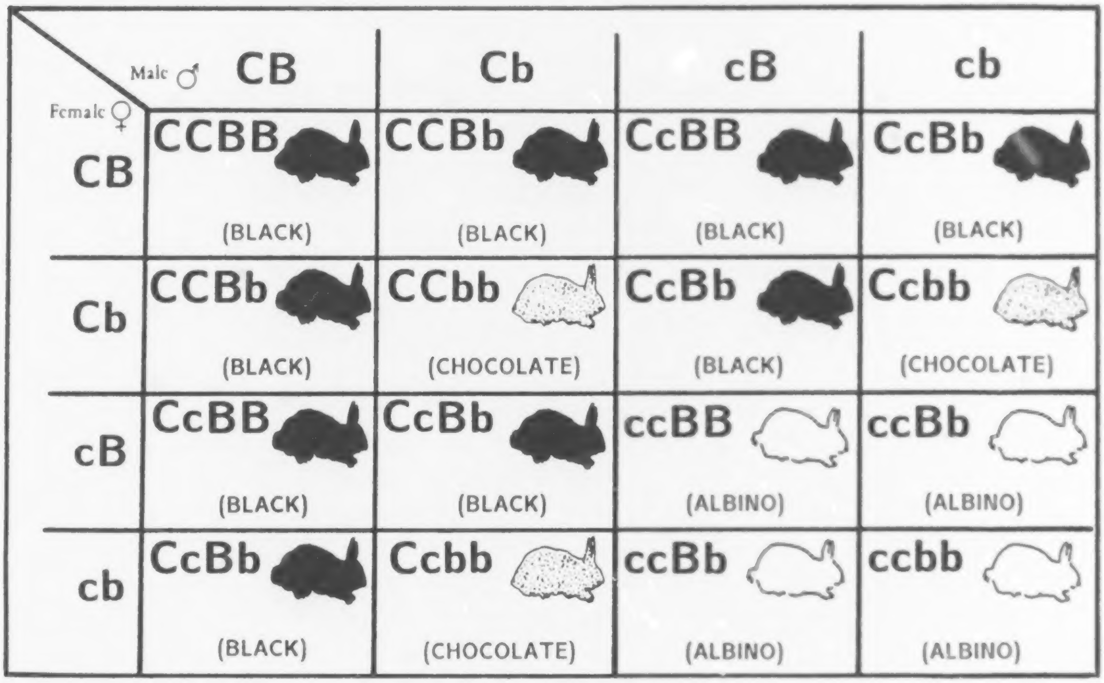
Basic Genetic Laws

Incomplete dominance - The phenotypic expression of a trait can also be the result of a lack of dominance. The coat color of Shorthorn cattle is a typical example of a lack of dominance. The two allelic genes involved are R for red color and W for white color. If the genotype of a Shorthorn is RR, it will be red; if its genotype is WW, it will be white. However, if its genotype is RW, the Shorthorn will be roan or a mixture of red and white.

In Shorthorn coat color, there are three genotypes and three phenotypes that are easily distinguishable. Mating a red Shorthorn (RR) to a white one (WW) results in roan (RW) offspring.

FIGURE 4.5 - Epistasis Exhibited by the Coat Color in Rabbits

Credit: *Agriscience 332H: Animal Science*



Male ♂ Female ♀	CB	Cb	cB	cb
CB	CCBB (BLACK)	CCBb (BLACK)	CcBB (BLACK)	CcBb (BLACK)
Cb	CCBb (BLACK)	CCbb (CHOCOLATE)	CcBb (BLACK)	Ccbb (CHOCOLATE)
cB	CcBB (BLACK)	CcBb (BLACK)	ccBB (ALBINO)	ccBb (ALBINO)
cb	CcBb (BLACK)	Ccbb (CHOCOLATE)	ccBb (ALBINO)	ccbb (ALBINO)

Epistasis - Epistasis is the interaction of two or more gene pairs that are not alleles, resulting in a phenotype that is different from the individual expression of the gene pairs. This type of inheritance is different from overdominance because overdominance results from the interaction of allelic genes. Epistasis affects animal phenotypes in different ways due to various interactions between nonallelic genes.

One example of epistasis is coat color in rabbits. Consider the possibilities of black, chocolate or albino (B=black, b=chocolate, C=color and c=albino). If a rabbit is homozygous for the gene for albino (cc), regardless of whether the individual carries genes for black or chocolate, it will be albino. However, if the offspring carries at least one gene for color (C), then the action of the other pair of genes is expressed. The gene for black (B) is dominant. Therefore, if an individual carries at least one black gene, it will be black. If the animal's genotype is bb and it has at least one gene for color, it will be chocolate. Figure 4.5 shows the possible outcomes if two rabbits that are heterozygous for both traits are mated. This is an example of a recessive epistatic gene greatly affecting all other genes for color.

There are various other combinations of epistatic genes, such as dominant epistatic, dominant and recessive epistatic, and pairs of recessive epistatic genes. Most species of animals have traits controlled by epistasis. The interaction between these gene pairs can be quite complicated, especially when many pairs of genes are involved.

Sex-linked traits - Some traits are sex-linked because they are carried on the X-chromosome that decides the sex of the animal. Remember, the female mammal has the genotype XX in the sex chromosome pair, while the male has an XY genotype. The X-chromosome is larger and longer than the Y-chromosome. Therefore, there is some portion of the X-chromosome that does not pair with genes on the Y-chromosome. There is also a certain portion of the Y-chromosome that does not link with the X-chromosome. Traits on this portion of the Y-chromosome are transmitted only from fathers to sons. Sex-linked traits are often recessive and are covered up in the female mammal by dominant genes.

Mutations - Genes can duplicate themselves. However, sometimes a mistake is made in duplication and a new gene called a mutation is born. This new gene will result in a change in the code sent by the mRNA to the protein formation process. Some mutations can cause a defect in animals, while others may be beneficial. Mutations are responsible for variations in coat color, size, shape, behavior, and other traits.

Law of segregation - As explained earlier, genes occur in pairs in the body cells. Because of the processes of meiosis and fertilization, an individual receives one gene from the father and one from the mother. Mendel's law of segregation and the recombination of genes shows that genes paired in body cells separate independently of each other. Therefore, there is a 50 percent probability that the offspring of an individual in the F_1 or first generation will possess a particular gene.

The probability that a particular gene will recombine during the fertilization process can also be predicted, provided no mutations or other chromosomal abnormalities occur. If two heterozygous individuals for a particular trait are mated (Aa x Aa), the probability that offspring will have certain genotypes is: AA (25 percent), Aa (50 percent), or aa (25 percent). As more genes become involved in a particular trait's heritability, the probability of selected genes recombining in offspring becomes more complex.

Summary

Much of the improvement in livestock results from using the principles of genetics. Genes control an animal's traits, and they are the basic units of heredity. Understanding the processes of gene action can assist in further genetic improvement in livestock.

Credits

Agriscience 332H: Advanced Animal Science (Student Reference). Texas A & M University: Instructional Materials Service, 1990.

Livestock and Poultry Breeding (Student Manual). 2nd ed. The Ohio State University: Agricultural Education Curriculum Materials Service, 1991.

Gillespie, James R. *Modern Livestock and Poultry Production.* 4th ed. Albany, NY: Delmar Publishers, Inc., 1992.

Lesson 5:
Tools for Genetic Improvement of Beef

Factors to consider when establishing a beef herd are: purebred or commercial, purebred or crossbred, price, adaptation, condition, age, longevity, health, herd size, and milking ability. Animal selection should be based on pedigree, individual performance and appearance, show-ring winnings, and performance testing.

Sire and Female Selection

Establishing a beef herd - There are several factors to consider before investing funds. There are two types of beef producers--the purebred operation and the commercial operator.

Purebred operators are a select few. They produce seed stock for commercial and other purebred operators. A higher investment is required to participate in a purebred operation because of the higher costs of breeding stock and facilities.

Commercial operators produce the majority of cattle in America. Their goal is to convert land, grass, and crops into a monetary form through traditional cow-calf operations, backgrounding, and feedlots. In commercial operations, crossbreeding is the most widely used breeding system. A commercial operator uses less capital to begin an operation than the purebred operator. The price of commercial breeding stock is comparable to market value or price.

The selection of a breed or deciding to use a cross is the next decision to make when establishing a beef herd. Purebred operators usually choose a breed based on personal preference or the breed with which they have had the greatest success.

This decision is difficult for commercial operators because of the increasing number of breeds and possible crosses. For instance, if there were 10 breeds of beef cattle, there would be 45 different single crosses and 360 possible three-way crosses from which to choose. But there are many more than 10 breeds of beef cattle (closer to 54 breeds). When establishing a beef herd, carefully research the decision on which breeds to use.

Consider milking ability when establishing a beef herd. The single most important factor in determining weaning weights is the ability of the mother to provide milk to her offspring. Remember, a lot of milk--a lot of calf, little milk--little calf!

A uniform herd is the goal of every purebred beef producer. Having the same size and color is essential for marketing in the purebred industry. If uniformity is lacking in a purebred operation, the life of that establishment will be short.

Uniformity is just as important in commercial operations as in purebred operations. Cattle buyers look for uniform size and muscling when buying cattle.

A beef producer must decide on the size of the herd. Several factors influence herd size. The first factor is the amount of labor needed to maintain the herd. An operator who runs a herd alone will probably have a smaller herd than one with three hired hands.

Quality is not determined by the size of the herd. Some of the finest beef stock are found on smaller operations. The cost of buying stock, cost of land, and the cost of facilities determine the size of herd.

No one wants breeding stock or market animals that are unhealthy. The purebred industry requires a certificate of health in the sale of an animal. Animals are tested for certain diseases before they are put up for sale. The health of beef animals is important to the future of the industry. When buying stock, remember to buy from operators and sale barns with strict health codes and reputations.

Consider the environmental conditions in the area, such as arid conditions of the southwest, the grain-producing Midwest, or the cold conditions of the northeast. Environmental conditions in certain areas are not suitable for certain breeds; this applies to both purebred and commercial industries.

When purchasing or selecting animals for breeding stock, always remember the importance of the animals' condition. Extremely thin or fat stock are detrimental to the herd because of low reproductive rates. Conditioning is a very important factor in selecting, purchasing, and managing stock in a herd.

Price is a very important factor because it will influence herd size and breed selection. The price of purebred animals is largely determined by the operator's reputation and the quality of stock.

Purebred animals bring more than market price because of the genetic superiority, extra costs associated with purebred operations, and the quality of stock. In the commercial industry, it is seldom necessary to pay more than market price for females, but it is beneficial to pay more for the sire to ensure genetic quality.

The final factors in establishing a beef herd are age and longevity of females. The longer a female can produce offspring that meets the standards set by the producer, the smaller the costs of buying replacement animals. Replacement animals are chosen based on price and the number of years remaining to produce quality offspring.

Four bases of selection in beef cattle - These bases are: (1) individuality and appearance, (2) production testing, (3) show-ring winnings, and (4) pedigree. Each method of selection has its own purpose, and it is up to the producer to emphasize one area of selection over another.

Selection based on appearance and individuality is completed using one of two methods--the traditional score card or the functional scoring system. The traditional score card lists individual body parts and gives them a numerical value. Body parts might include flank, rump, loin area, structure, head, and neck. A perfect score is 100 points. Each breed association has developed its own score card for the breed. This system is very valuable because looks can be deceiving.

The other individuality/appearance method is the functional scoring system. Here, the parts of the animal are divided into areas. Reproductive efficiency, muscling, size, freedom from waste, structural soundness, and breed type are the six areas in which the animal is divided. Numerical values are also given to each area for a maximum of 100 points.

Each area has economic importance. Reproductive efficiency is divided by gender. A female must have a long body, leanness, sound udder structure, smooth muscles, functional udder, and feminine characteristics to score 20 points. A male must possess masculine traits, muscling, well-developed genitalia, equal-sized testicles, and proper neck-to-scrotum length to score 20 points.

Muscling is also awarded 20 points. Muscles need to be smooth and round, not square, and must bulge and move when walking. Loin muscle must bulge on both sides to score well. Muscling applies more to bulls and steers than heifers.

Size is awarded 15 points. Animals must have adequate height at the hip and shoulder, adequate length of body, and leanness to score 15 points. Avoid early maturing bulls because they will lack growth spurts as they grow older.

Freedom of waste is also awarded 15 points. Trimness in both breeding and slaughter animals is very important. Fat animals have lower reproductive rates and lower carcass quality. As a producer, avoid loosely hided animals.

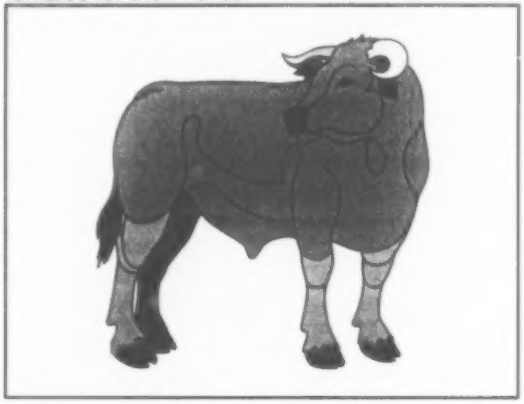
Structural soundness is also awarded 15 points. Animals must possess squarely set legs that are straight and true, squarely set toes and hocks, and equally sized toes to score 15 points. Avoid animals with hocks and joints that appear swollen.

Breed type is awarded 15 points. The animal must show signs of the breed, such as proper color; body markings, shape, and size; polled or horned; and proper shape of the head.

In general, selection based on performance testing can be described as the record keeping or data collection of the progressive stages of an animal. Data should be collected on birth weight, weaning weight, yearling weight, rate of gain, feed efficiency, pasture gain, feedlot gain, carcass traits, and conformation score. Collect data throughout different stages in the animal's life. This information is helpful when selecting animals because of the measurable traits.

Selection based on pedigree is used to judge future performance of offspring based on past performance of parents and ancestors. Selection based on pedigree is used more often in the purebred industry than in the commercial industry. Traits such as fertility, birth weight, weaning weight, rate of gain, and carcass traits all have economic importance and are transferred by inheritance. This demonstrates the importance of performance testing and pedigree selection.

Selection based on show-ring winnings is used often in the purebred industry. Animals that consistently win in the show-ring circuit are looked on favorably by producers in the purebred industry. Judges look for different characteristics each year when consumer needs change; that is why there is such an emphasis on show-ring winnings. Show-ring winners bring higher prices, though. Commercial producers also use the show-ring circuit to choose outstanding sires and females for their herds.



Crossbreeding and Hybrid Vigor

Crossbreeding is the breeding system that mates two or more different breeds to gain more quality traits. Crossbreeding is used for several different reasons. First, it increases productivity over purebred animals in the form of hybrid vigor. Second, it produces animals with a combination of desirable traits that are not found in any specific breed. Finally, crossbreeding produces foundation stock for new breeds.

Advantages - Crossbreeding introduces new and desirable genes quickly or at faster rate than selection within a breed. A good example is crossing a dairy breed to a beef breed to increase milking ability in the beef herd. Using a dairy sire to mate beef females will increase milking ability in one generation. If selecting from within a breed, it may take several generations to increase milking ability in the herd.

Another advantage is hybrid vigor or heterosis. Hybrid vigor is a biological phenomenon that causes crossbred offspring to outproduce the average of their parents. Hybrid vigor occurs because a dominant gene in a parent is usually more favorable than its recessive partner. When two separate gene pools are mixed together, the traits that may have been lacking now become superior with the mixture of genes. The example of crossing the dairy and beef animals explains the essence of hybrid vigor.

The use of complementary traits is another advantage of crossbreeding. Here, two or more characteristics complement or combine with each other. This results in the maximum desired traits in a cross. Each breed is known for certain desirable characteristics, and matching them with another breed that lacks those desired traits is referred to complementary crossing.

Types of crossbreeding - A two-breed cross mates a purebred sire to a purebred female of a different breed. Hybrid vigor only appears in the offspring, which is a limitation of this crossbreeding system. Another limitation is that the cross does not make use of a crossbred female.

A two-breed backcross or crisscross involves the use of a sire of breed A mated with a female of breed B. The offspring is then backcrossed to either breed A or B, resulting in a 1/4 to 3/4 breed. Mating a purebred Hereford sire to a purebred Angus female, then mating the offspring to a purebred Hereford or Angus sire, will result in a two-breed backcross or crisscross.

A three-breed rotational cross is another crossbreeding system. A rotational cross involves mating a purebred Beefmaster sire to a purebred Angus female, mating the offspring to a purebred Hereford sire, and then mating this offspring back to a purebred Angus sire, so that all three breeds had sired the offspring. Hybrid vigor will appear in all sets of offspring.

The last crossbreeding system is the three-breed fixed or static cross (terminal cross). This system mates a crossbred female (two-breed cross) to a third breed sire, which results in a three-breed fixed or static cross. In this system, all offspring are sold. When replacement females are needed, new females of the same two-way cross are purchased. A limitation of this system is buying the same quality of replacement females of the same cross. An example of a terminal cross is breeding a purebred Holstein sire to an Angus-Hereford cross female.

EPDs and How They Are Used

Expected Progeny Differences can be used to estimate how future progeny of the subject animal will compare to progeny of other animals within the breed. EPDs are designed to compare bulls based on estimated performance of the progeny, not to predict the performance of one or two progeny of a sire.

On the average, a bull with an EPD score of +50 lbs. yearling weight would be expected to sire calves 20 lbs. heavier than a bull with +30 lbs. yearling weight.

EPDs are used heavily in all phases of beef enterprises. Purebred and commercial herd owners use EPDs to select sires for different production traits.

Accuracy and reliability - The accuracy figure (ACC) is the reliability measure of the EPD. An accuracy of 1.00 is of the highest reliability. Accuracy is categorized as low (0.00 to .5), medium (.51 to .75), and high (.76 to 1.00). With low ACC, the possible change in pounds is high.

Reliability is increased as the number of progeny reported per sire increases (and decreases the amount of EPD change). For example, an ACC of .2 for weaning weight means that the EPD can change ±13.8. An ACC of .9 in the same trait and breed means weaning weight could change ±1.7 for that sire.

These numbers are examples of standards set up by breed associations. In Table 5.1, Bull A has an ACC figure of .91, which means a calf sired by Bull A will have a weaning weight of 22.2-25.6 pounds heavier than Bull B. Another example of ACC figures is that a .2 ACC for birth weight represents ±3.1 lbs.; a .9 ACC figure represents ±.4 lbs. This means a calf sired by Bull A will have a birth weight of 7.1-7.9 lbs. heavier than Bull B.

Table 5.1 shows an example of sire summary data for EPDs on four sires.

Summary

Application of sound selection methods and usage of EPDs are vital for beef producers to stay on the cutting edge of beef production.

Credits

Ensminger, M. E. *Animal Science Digest.* Danville, IL: Interstate Publishers Inc., 1991.

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

University of Missouri-Columbia Extension Division agricultural publication

a) GO2032: Understanding and Using Sire Summaries

TABLE 5.1 - Sample Sire Summary Data

Sire	Birth weight		Weaning weight		Yearling weight		Milk	
	EPD	ACC	EPD	ACC	EPD	ACC	EPD	ACC
Bull A	+7.7	.93	+29.6	.91	+42.3	.78	-20.3	.85
Bull B	+0.2	.67	+5.7	.7	+29.1	.42	+4.9	.4
Bull C	+6.5	.89	+39.3	.85	+62.0	.72	+16.5	.72
Bull D	+0.5	.05	+10.2	.05	+31.1	.05	+8	.05

Lesson 6:
Selection Tools for Genetic Improvement of Dairy Cattle

Of all the species of livestock, dairy cattle are the most specialized in their performance area. They are expected to produce the most milk on the least amount of inputs. For this reason, genetic selection for optimal performance is an important factor when selecting individuals to be included in a dairy operation. (See Table 6.1.)

Selecting Dairy Cows and Heifers

Breed selection - The five common breeds of dairy cattle are Ayrshire, Brown Swiss, Guernsey, Holstein, and Jersey. Although there is no one best breed, there might be a particular breed that is favored by an individual dairy producer because it is better suited for certain farm conditions and market demands.

Selecting a breed of dairy cattle is like selecting any other item where an individual has a variety from which to choose. After considering all the advantages and disadvantages, personal preference may be the determining factor.

Consider each of these factors in selecting a dairy breed for an individual dairy operation.

1. The availability of breeding stock of the type and quality that is desired
2. The producer's markets for milk and butterfat
3. Availability of forage crops and pastures (since the larger and more rugged breeds require more roughage)
4. Climatic conditions, because breeds differ in ability to withstand temperature extremes
5. Age of maturity, since heifers of larger breeds do not usually mature and come into production as early as the smaller breeds
6. Local popularity of a breed (for marketing surplus stock and breeding stock availability)
7. The size and vigor of newborn calves, especially in relation to replacement prospects and for calving difficulties

Individual selection - Four factors are usually involved in selecting individual dairy animals: (a) type or physical appearance, (b) production records, (c) pedigrees, and (d) health and vigor.

Certain physical characteristics are associated with high milk production. Since type and production are closely related, it is important to become familiar with the correct or ideal dairy type. Understanding these characteristics makes it possible to judge the productive capacity of an animal before production records are available or when records are unavailable.

Fat test	50
Protein test	50
Size	50
Birth weight	45
Weight	35
Gestation length	35
Fore and rear udder	35
General appearance	33
Type	30
Dairy character	30
Milk yields	25
Mastitis	25
Breed character	25
Milking ability	24
Body capacity	23
Udder depth	22
Teats, veins, and quality	20
Feet and legs	18
Longevity	10
Udder size and shape	7
Teat length	5
Reproductive performance	3
Service per conception	3

The five major dairy breed associations in the U.S. have cooperated through the Purebred Cattle Association to develop a unified score card for dairy cows and bulls. This card indicates points to be considered in selecting dairy cattle and the emphasis to be placed on each area.

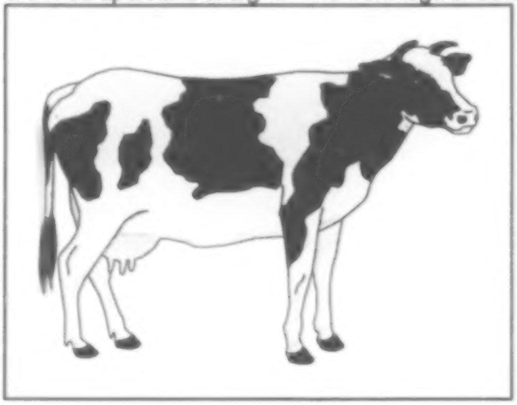
Dairy producers who use trait evaluation as a guide in selecting sires and mating cows find they can improve production, increase the number of profitable lactations, and reduce herd replacement numbers. This linear classification program measures precisely and uniformly all descriptive functional traits known to have a bearing on production of the animal.

Form includes stature, strength, body depth, and angularity. The classifier must study several features, such as the cow's measurement from the ground to the top of the withers, width and depth of the chest, muzzle width and substance of bone in the front end, depth of rib cage, rib openness, neck length, and sharpness and flatness of bone.

Rump evaluation includes angle, length, and width. Blending smoothly from the loin, the rump should appear long from the side and wide from the rear view. The distance between the hip and the pin bones determines the length of the rump. The thurl, or area between the hip and pin bones, should appear high, level, and full as viewed from the side, and both thurls should be wide apart as viewed from the rear. The tail head should blend neatly from the rump and set squarely between the pin bones.

The condition of the *legs and feet* is most important when evaluating general appearance. A cow must be correct on her feet and legs to endure the physical demands of milk production and to avoid lameness. Starting with the feet, the soles should be level to the ground and the hooves should be at a slight angle and evenly placed to avoid the toeing-out condition.

It is helpful when evaluating a cow's legs to see the cow walking. Regardless, the bones of the cow should appear flat, strong and smooth. The rear legs should be placed squarely under the body with only a slight curve to the hock as viewed from the side. A rear view should show legs that are wide apart and straight. The front legs should also be straight and square under the cow when viewed from the side. A front view should show legs that are wide apart, allowing for good width to the chest.



Credit: *Agriscience 332: Animal Science (Student Reference).* Courtesy of Instructional Materials Service, Texas A & M University, College Station, Texas. Appreciation is extended to IMS for use of portions of the *Agriscience 332: Animal Science* instructional materials.

Most dairy producers will agree that the *udder* is the cow's most important body part. Udders with defects or poor conformation can produce less milk or be more susceptible to infection and injury.

The udder should first be divided into sections for an evaluation, and then it should be evaluated as a whole. The fore udder should have moderate capacity. It should be long and curve smoothly into the cow's underline. The rear udder should extend high and wide. It should appear strong, have a well-defined cleft and attach smoothly in the rear. All four quarters of the udder should be rounded and balanced. The four teats should be convenient in size, spaced evenly at the corners of the udder and appear perpendicular to the floor of the udder. A prominent mammary vein is desired, but it is not as emphasized as it has been in the past. The udder tissue or secreting tissue is soft, pliable, and spongy to the touch. Any firm or fatty tissue is discriminated against.

Production records - Much of the guesswork is taken out of selecting dairy animals by production records. They show the productive capacity of the cow and give an indication of the possible production of the offspring. Since a purebred's production records and its ancestors are recorded on the pedigree, increasingly large numbers of dairy herds are being tested in dairy herd improvement association programs.

Dairy producers who keep production records usually keep one of the following types: (1) DHIA (Dairy Herd Improvement Association) or (2) Owner-Sampling Testing Records. Both of these types involve weighing the milk produced by each cow in the herd one day a month.

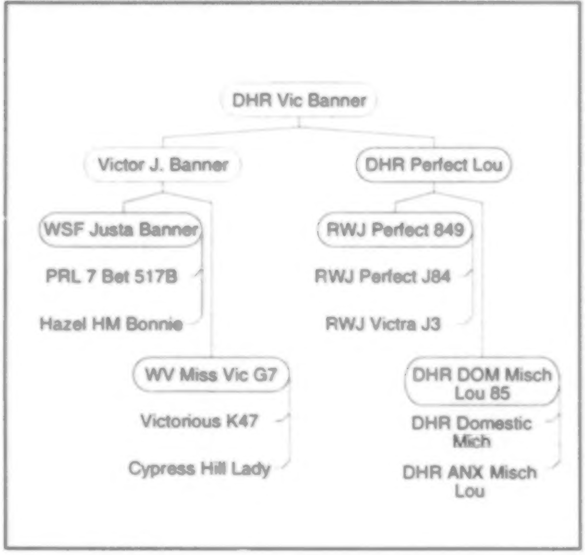
The DHIA, which is supervised by the USDA and the local DHIA Board of Directors, provides the most information on production and feeding for each cow in the herd. An approved tester does actual testing by visiting the dairy one day each month to weigh and sample milk, make butterfat tests, and calculate production and feed records. This information is sent to a data processing center for computation and summarization and is then returned to the dairy producer.

The report contains an individual cow's records, such as daily milk weights, butterfat percent, concentrates fed, reproductive status, value of milk produced, feed cost, and income-over-feed cost. It also has a herd summary for the test period.

Owner-sampler records are kept by dairy producers interested in a less expensive herd improvement and testing plan. Producers using this plan weigh and sample each cow's milk one day each month; a tester picks up the samples and calculates the results. Because dairy producers takes their own samples, this is not an official test.

Pedigrees - The pedigree lists the animal's ancestors and might also include production records and type classification of the animal and its ancestors. It might also carry summaries of any official production records made by the animals involved. Most pedigrees show three generations. (See example pedigree in Figure 6.1)

FIGURE 6.1 - Sample Dairy Cow Pedigree



Breeders of purebred cattle carefully study the pedigree of each animal before it is added to their herds. When using the pedigree as a basis of selection, the most consideration should be given to the sire and the dam because they contribute 50 percent to the animal's makeup. Other ancestors contribute the other 50 percent.

The more production records shown on the pedigree, the more reliable the information will be concerning the animal's possible production capacity. When comparing animals within a pedigree or comparing the pedigrees of different animals, the milking records should be equivalent as to the days and age; otherwise, the records should be adjusted so they are equivalent.

Health and vigor - The general health of the herd can be determined by the calving record of cows during the past year, the number of cows in production, stages of production, and the amount of milk being produced.

The most serious causes of health problems in dairy herds are sterility, mastitis and other related udder infections, Bang's disease (brucellosis), leptospirosis, and tuberculosis. It is desirable to buy animals only from herds that have been vaccinated or tested for Bang's disease and have been tested for tuberculosis and leptospirosis. If animals purchased have not been tested within the last 30 days for Bang's disease and tuberculosis, the animals should be tested before being purchased. To minimize health problems, one should select animals from a reputable breeder of a disease-free herd.

Sire Evaluation Data

Production of sires - The planned mating of superior cows and bulls can produce superior sires for artificial insemination. Cows which produce 4,000+ pounds of milk above herd mates and half-siblings producing 2,000-3,000+ pounds above herd mates are usually used for such matings. Also, take note of cow families for desirable conformation type, longevity, good temperament, and reproductive efficiency.

Mate the cow with a superior AI stud for high PD and repeatability. Semen collection from the offspring begins at 10-12 months of age. Then, in herds throughout the U.S., enough cows are mated with the young bull to obtain 50-100 production-tested daughters. The bull is placed "on the shelf" for 4-6 years until daughters mature and provide milk production records. Bulls with high PDs (Predicted Differences) are widely used.

Sire selection - Various indexes can be utilized to select a dairy sire.

1. Daughter average - selection based on the average production of the sire's daughters
2. Daughter-dam difference - considers the amount of increase or decrease in milk produced by a bull's daughters when compared to their dams
3. Equal-parent index - based on the premise that the sire and dam contribute equally to the inherent milk-producing ability of the progeny. It is equal to twice the average production of the daughters, minus the average production of dams.
4. Daughter-contemporary herd difference - substitutes the herd average for the dam's average in the daughter-dam difference index. The sire index is equal to the daughter's average minus the herd average.
5. Daughter-contemporary herd index - substitutes the herd average for the dam's average production in the equal parent index. The sire index is equal to twice the average production of daughters, minus the herd average.
6. Herd mate comparison - compares a sire's daughters with cows (herd mates) that freshen in the same herd during the same season of the same year. This index removes most environmental differences, such as the season of calving.
7. Adjusted herd mate average - adjusts each lactation of a sire's daughter for comparison with one another
8. Predicted Transmitting Ability (PTA) - an estimate of the amount of superiority (improvement) or inferiority an animal will transmit to its offspring. It is the most accurate measure available of an animal's genetic ability.

For herd improvement, a dairy producer should choose from the following: (1) bulls with the highest PTA, (2) bulls with high PTA values that also have high reliability values (narrow confidence intervals), (3) several bulls with high PTA values when the reliability value is below 75 percent, and (4) bulls with a low percentage of difficult births when breeding heifers.

Summary

When selecting for high-production dairy cattle, producers must evaluate the genetic potential for milk production, as well as visual selection for conformation. Production records help determine how long the cow will stay in the herd by providing information on good feet and legs, proper udder attachments, etc. Therefore, study the overall picture before making major decisions on replacement heifers/cows and sires.

Credits

Advanced Dairy Unit. University of Missouri-Columbia: Instructional Materials Laboratory, 1987.

Agriscience 332H: Advanced Animal Science (Student Reference). Texas A & M University: Instructional Materials Service, 1990.

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Lesson 7:
Tools for Genetic Improvement of Sheep

Factors to Consider When Establishing a Sheep Flock

The first decision to make before establishing a flock is the kind of stock to be used for breeding or foundation stock. The final selection (purebred, crossbred, or grade stock) is usually made based on personal preference or the amount of experience a producer has with the breed. Purebred operations usually demand much more experience with sheep production than either crossbred or grade stock. Most sheep producers elect to use a purebred ram and high-grade ewes for their operations. There are considerable price differences between purebred and crossbred stock.

After deciding the type of production desired, select a breed or breeds. This is usually done by personal preference, but some research needs to be done on types of traits desired. Breed selection is based on traits such as herding ability, long or fine wool, size, mutton or wool type, and adaption to environmental conditions in the area.

Environmental conditions are important in choosing native or western stock. Native ewes are sheep produced outside the western range area and are known for their mutton-type breeding. Native sheep are usually larger in size and usually cost more than western sheep. Western sheep are usually smaller in size and are less expensive to buy. Western sheep are parasite resistant, a vital characteristic in the western ranges of the U.S. Western sheep are usually a fine-wool by long-wool cross, which is also essential for range production.

Uniformity is the next important factor to consider when establishing a flock. It is essential to have uniform market lambs and have the same quality of wool when marketing these goods. Therefore, breeding stock should be selected by uniform size, conformation, and fleece quality.

The ram should be selected to match female stock (for ease of breeding) and for desirable traits.

The size of flock or band is the next factor to consider when establishing a flock. This is usually determined by the experience of the operator, capital, amount of land, and the method of management. Larger operations are usually commercial or grade flocks. Smaller flocks usually consist of purebred operations. A beginner can gain valuable experience through a small flock without subjecting a larger flock to this inexperience.

The most favorable time to begin a sheep operation is in the late summer when lambs are weaned and before the ewes are bred.

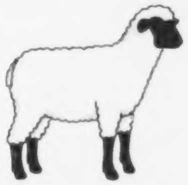
When establishing a sheep flock, healthy animals are critical to the herd's success and longevity. All breeding stock purchased or raised should be thrifty, vigorous, in good condition, and capable of producing healthy, strong offspring. If stock cannot produce under these conditions, they should be culled and replaced. Obtain health papers with purebred animals to ensure their health.

Age is an important factor to consider when purchasing sheep for a new flock. Older breeding stock is considered a poor investment in the sheep industry. Fleece can cover up problems that older breeding stock have; therefore, it is wise to invest capital in yearling ewes to avoid getting someone else's problems. Another plus with younger stock is that replacement costs should not appear for several years. Working with younger stock lets the operator see problems that might advance in several years.

Soundness of udder is an important factor to consider when selecting sheep to establish a flock. This requires the touch method and careful observation. Udders should be soft and pliable. There should be four working teats of equal size and shape. Any ewes that are missing teats or have meaty or abnormal teats should be rejected. Unsoundness of the udder will decrease production of the flock.

Price is the last factor to consider when establishing a flock or band. Cost is like any other livestock production operation--premiums will be paid for quality foundation stock. Price is usually based on the animal's ability to produce quality wool and offspring. The lower price of sheep should be considered when choosing a beginning livestock operation. Like other livestock operations, purebred stock is generally higher priced than crossbred or grade stock.

Selection methods - There are four criteria or methods used when selecting sheep for production and breeding stock. These four selection methods are based on: type and individuality, pedigree, show-ring winnings, and production testing.



With the presence of fleece, the selection based on type and individuality becomes difficult. Selection should not be based on observation only. Production records are very important when selecting stock for the flock. The "touch method" helps eliminate fleece-covering problems. The touch method helps determine economically important traits such as muscling, loin area, leg of lamb, and udder problems. This method is used in culling ewes, eliminating light-fleece animals, and removing wool-blinded animals.

Like cattle, sheep have a score card to use when evaluating them for type and individuality. Like cattle, the score card places numerical values on different parts of the animal. A perfect score is 100 points.

Without a doubt, selection based on pedigree carries less weight in sheep than in any other livestock selection. It is rare to find a commercial producer contemplating a purchase because of the pedigree. More pedigree emphasis is put on stud rams than ewes. However, blood lines do influence the price of purebred stock.

Selection based on show-ring winnings in sheep is like other livestock in that show-ring winnings dictate consumer wants and needs. Therefore, show-ring winners and their progeny are in great demand. Show-ring winners are usually a good investment if the producer is willing to pay premium prices, particularly in a purebred operation. Remember, show-ring winners represent other people's needs and demands, not necessarily the individual producer's.

As with other livestock, selection based on production/performance testing is emphasized a great deal by producers and sheep buyers. Unlike other livestock, sheep offer two products instead of one. Wool production is more prominent in the southwestern part of the U.S., and mutton production is more prominent where feed grain is more abundant.

Sheep production testing is divided into two areas: mutton and fleece production. Producers emphasize that production testing in sheep is a more accurate method of selection than any other method. Remember, production testing evaluates traits that have economic importance on the operation. Records are kept on traits such as multiple births, birth weight, weaning weight, rate of gain, fleece grade, and loin area.

Crossbreeding Systems and Hybrid Vigor

Crossbreeding is the mating of two animals of different breeds to combine the desirable traits of each animal. Crossbreeding helps produce two quality products, mutton and wool, from the same animal. Crossbreeding is also used because of the diverse conditions in which sheep are expected to produce. Hybrid vigor is a major factor in determining if a crossbreeding program will be used in a sheep production operation.

Advantages of crossbreeding - Hybrid vigor (heterosis) is a crossbreeding program benefit. Hybrid vigor is the biological phenomenon that causes crossbred offspring to outproduce the average of their parents. Another advantage to a crossbreeding program is introducing new, desired genes quickly or at a faster rate than simply selecting within a breed. Crossbreeding in sheep increases the yield of females at a much faster rate than same-breed breeding.

The last advantage of crossbreeding is the maximizing of desirable traits and the minimizing of undesirable traits. Complementary traits involve combining the most desired traits in one cross or generation. Since rams and ewes do not contribute equally in offspring, sheep are divided into ram breeds and ewe breeds.

Types of crossbreeding systems - A two-breed cross involves mating a purebred ram of breed A to a purebred or high-grade ewe of breed B. The offspring will have hybrid vigor as a result of this cross. A two-breed backcross or crisscross mates a purebred ram of breed A to a purebred or high-grade ewe of breed B, then mates the offspring back to a purebred ram of breed A or B. The offspring of both generations will have hybrid vigor as a result of this cross.

A three-breed cross mates a purebred ram of breed A to a purebred ewe of breed B, then mates the offspring to a purebred ram of breed C before mating the offspring back to a purebred ram of breed B. The offspring of all three generations will have hybrid vigor as a result of this cross.

Using Performance Data

The National Sheep Improvement Program or (NSIP) is a tool which helps sheep producers improve their efficiency in lamb and wool production. The program was solely developed for genetic improvement for sheep flocks. The NSIP is a computer-based program that provides output on the most accurate estimates of genetic merit for economically important traits for individual sheep anywhere in the U.S. This computer-based program can usually be found at any county extension office. For a producer to receive feedback from this program, the producer must first provide some input from the flock, although the NSIP also provides EPDs on other sheep for selection purposes.

Input needed for NSIP - First, there must be data collected on the ewes in the flock for each year, such as: the number of lambs born, the number of lambs reared, weights at birth, and weights at various days (30, 60, 90, 120, 240, or 365), gains between designated ages, ram days to lambing, fleece weight (as a yearling and annually thereafter), staple length, and fleece grade of the side and britch (hind quarter). (The micron count is optional.) Of the various day weights listed above, only three are needed.

There must also be data collected on individual sheep in the flock, such as: individual lamb identification (ID) number, sire ID number, dam ID number, type of birth, sex of lamb, type of rearing, date ewe was exposed to ram, date lamb was born, weights at birth, and weights at various days (30, 60, 90, 120, 240, 365), fleece weight, fleece grade of side and britch, micron count, and staple length. Of the various day weights listed above, only three are needed.

Other options for data collection are whether a birth was assisted or unassisted, face scores, wrinkle scores, shoulder height, and carcass merit. With the following information entered into the NSIP computer program, producers can evaluate their flocks.

Types of output from NSIP - The three types of available output are: flock genetic evaluation summary, ewe lifetime production summary, and flock management summary.

The flock genetic evaluation summary is considered the most important output. It provides accurate estimates of genetic merit for every ewe, ram, and lamb in the flock. Measurements are provided by the inputs previously taken on ewes and individuals in the flock.

The flock genetic evaluation summary also provides EPDs on sheep in the flock and other sheep across the country. An EPD (Expected Progeny Difference) is calculated the same way in sheep as it is in cattle. A ewe with a +3.2 for 90-day weight (See Table 7.1) should produce lambs that are +3.2 lbs. heavier than an average lamb in the flock. An average lamb has a 0 EPD rating. A ewe with -1.7 for 90-day weight (See Table 7.1) will produce lambs that are expected to be -1.7 lbs. lighter than an average lamb in the flock. EPDs are also available for rams.

The accuracy figure (ACC) indicates how much an EPD will change if additional progeny data is collected. A high value indicates that there will be little change when additional progeny data is collected. For example, an accuracy figure of a .90 indicates a higher degree of accuracy than a .72 accuracy figure.

A lifetime production summary is provided for each individual ewe in the flock. It contains the ewe's pedigree, performance as a lamb, lambing

TABLE 7.2 - Sample Ewe Summary Data

Dam	30-day weight		60-day weight		90-day weight	
	EPD	ACC	EPD	ACC	EPD	ACC
Ewe A	0	.80	+1.2	.86	+3.2	.90
Ewe B	-.9	.79	-1.0	.72	-1.7	.87
Ewe C	+1.2	.88	+2.3	.92	+5.4	.96

intervals, lambs born and weaned, and actual performance of every lamb to which she has given birth. This type of output is very useful for purebred producers to promote specific ewes and their progeny. This output also aids commercial producers in identifying truly outstanding ewes and deciding which progeny to purchase.

Flock management summary provides a summary of the average performance of the flock for the present production year and the previous year. The output provides distribution of lambing from the start of lambing season, age distribution of ewes, percent of single and multiple births for age groups, and reasons for culling and deaths. This output helps monitor flock performance and identify flock and management strengths and weaknesses.

Overall, the NSIP supplies the producer with an informative summary of the flock on both production and genetic traits. As said previously, the NSIP is a tool to aid producers in improving their efficiency in lamb and wool production. The producer must put forth some effort (data collection and data input) in order to receive the benefits from this program. With appropriate producer effort, benefits will be reaped ten-fold.

Summary

It is critical for sheep producers and those in related occupations to use available resources in sheep selection and flock improvement. These resources can be beneficial in genetically improving any flock.

Credits

Ensminger, M. E. *Animal Science Digest.* Danville, IL: Interstate Publishers Inc., 1991.

Thomas, D. "National Sheep Improvement Program: The Means to an End." *National Wool Grower* June 1989: 30-33.

Lesson 8:
Selection Tools for Genetic Improvement of Swine

Independent swine producers have either seed stock or commercial operations. In a commercial operation, hogs are produced and sold for slaughter. The slaughter animals are nearly always crossbred. Independent seed stock producers supply boars and/or gilts to be used as breeding stock in commercial herds. The animals can be purebred or crossbred. Seed stock producers also sell a part of their progeny for commercial slaughter. The breeding stock used by commercial producers is usually purchased from an individual seed stock producer or a corporate breeding company. Regardless of the type of operation, both producers keep alert for ways to genetically improve their herds.

Breeding Stock Selection and Production

Most swine breeding systems involve production and crossing of specialized sire and dam lines. These lines can be purebreds or composite lines. Eight major breeds are represented in the United States: Duroc, Yorkshire, Hampshire, Landrace, Chester White, Berkshire, Spot, and Poland China. Breed associations maintain registries for each of these breeds.

Commercial breeding companies and some large independent seed stock producers maintain composite lines. These homogeneous lines of animals have been developed from crosses among two or more breeds and subsequently closed to new animals. The composite lines are then managed much like a pure breed with all replacements selected from within the population.

Performance testing - For seed stock producers to remain competitive, they must make continued genetic improvement of their breeds or lines. A practice necessary for genetic improvement is *performance testing*. Performance testing is the practice of measuring the performance of the pigs in a herd for traits of economic importance.

Traits that are economically important to the swine producer include:

1. Litter size
2. Litter 21-day weight
3. Growth rate
4. Back-fat thickness
5. Loin eye area
6. Feed efficiency

Each trait impacts the producer's income. Litter size is usually considered the most important trait. It is relatively difficult to improve litter size through selection; however, it can be improved by good management practices and by using crossbred females of breeds with high reproductive rates. Litter 21-day weight indicates the female's reproductive rate, piglet survival, and milking ability of the dam. Heavy 21-day weights ensure pigs with a good start following weaning. Growth rate is important because rapidly growing pigs make efficient use of growing/finishing facilities.

Loin eye area and back-fat thickness help decide the slaughter hog price. Most pigs are now sold on some type of lean value program with price determined by a predicted percentage lean in the carcass. Greatest prices are commanded by pigs with a small amount of back-fat and large loin eye area.

Feed efficiency is related to the cost of production per unit. Feed efficiency is difficult to measure directly because it requires measurement of individual feed consumption. Fortunately, feed efficiency is closely related to the combination of back-fat thickness and growth rate. These two traits are easily measured and can contribute to improved feed efficiency.

For performance testing, pigs must be identified using a marking system, ear tags, or a standard pattern of ear notches. The performance of the pigs must be measured and recorded. The performance testing program can be as simple as recording litter size, the birth date of pigs, their date of slaughter and market weight. From these records, weight per day and days to slaughter can be calculated without even weighing a pig! However, since this information is only available on animals that are slaughtered, its use is limited to determining seasonal differences in perfor-

389

mance, which might indicate need for management changes or progeny testing of sires in the herd.

Much genetic progress can be made by diligently measuring economically important traits and by using the information to make selection decisions.

Back-fat thickness - The next step up in complexity of performance testing involves weighing pigs and measuring back-fat thickness. A scale and back-fat probe are needed to take these measurements. These tools allow the calculation of 21-day litter weights, gains during the growing and finishing periods, and measurement of leanness.

Before records can be further processed, they must be adjusted to a common basis of comparison. Various factors, such as animals being reared in litters of different sizes, can affect their weight and can result in unfair comparisons if made on the raw data. Likewise, if ultrasonically measured for back-fat thickness, animals that are heavier at the time of measurement are at a disadvantage compared to lighter weight animals.

Adjustment factors have been calculated that help eliminate known sources of error. An example of this is shown in Table 8.1. The National Swine Improvement Federation produces publications that contain adjustment factors. Contact a local extension office or the state swine extension specialist for more information.

An alternative to adjusting records by hand involves using computer software such as "PigChamp," "PigTales," or other programs.

EPDs - At the highest level of performance testing, records are used to evaluate breeding values or expected progeny differences (EPD). These are statistically based combinations of information on one or more traits from an animal and its relatives. EPDs are the current state-of-the-art for estimating an animal's genetic merit.

The difference between EPDs for two boars is the expected average difference in performance of the boars' progeny for a particular trait. For example, if the boars' EPDs for days to market were -7 and -3 days, respectively, progeny of the first boar would be expected, on average, to reach market four days sooner than progeny of the second boar.

For maternal traits such as litter size and 21-day litter weight, the performance of the daughters of the two boars is compared. For example, if the EPDs of two boars for litter size were +1.5 and -1.1 pigs, respectively, daughters of the first boar would be expected to produce litters averaging 2.6 more pigs per litter.

Heterosis and Crossbreeding

Crossbreeding is a common swine production practice in Missouri and throughout the country. Approximately 95 percent of swine that are commercially slaughtered are crossbred. There are two reasons for crossbreeding in commercial production. For many production traits, heterosis

Table 8.1 - Calculating Adjusted Back-fat

Compare back-fat thickness of two boars. Boar 2-12 measured .72 inches when it weighed 223 pounds, and Boar 3-3 measured .80 inches when it weighed 245 pounds. For a fair comparison of leanness, the back-fat depths should be adjusted to a common weight at measurement. The National Swine Improvement Federation adjustment factor for back-fat thickness is:

$$\text{Adjusted back-fat} = \text{actual back-fat} + \frac{(\text{desired weight} - \text{actual weight}) \times \text{actual back-fat}}{\text{actual weight} - 25}$$

$$\text{Adjusted back-fat for Boar 2-12} = .72 + \frac{(230 - 223) \times .72}{223 - 25} = .75 \text{ inches}$$

$$\text{Adjusted back-fat for Boar 3-3} = .80 + \frac{(230 - 245) \times .80}{245 - 25} = .75 \text{ inches}$$

The adjusted values indicate that although Boar 2-12 had less back-fat when the two boars were probed, if they had been measured when their weights were equal, their back-fat would have been the same.

(hybrid vigor) is favorably expressed by the crossbred animal. Back-fat thickness is an exception; it tends to be greater in the crossbred offspring than the average of the purebred parents.

The second reason for using crossbreeding is to merge the desirable characteristics of two breeds into a single animal. The ability to combine specialized maternal or terminal characteristics of a breed is known as *breed complementation*. (Terminal lines refer to lines where all progeny are sold.)

Heterosis - In a crossbreeding system, individual heterosis is expressed by the crossbred progeny. Individual heterosis is measurable for traits such as growth rate and feed efficiency. Maternal heterosis is expressed by crossbred sows, affecting progeny performance for traits such as 21-day litter weight. Paternal heterosis is expressed by crossbred boars for traits such as sperm production and libido.

The amount of heterosis expressed in any cross is related to the common breed makeup of the parents and is described as a percentage. If the two parental breeds share no common breed makeup, heterosis is maximized at 100 percent. In a backcross, when a Hampshire x Duroc sow is mated to a purebred Hampshire boar, for example, heterosis in the offspring is 50 percent because the sire and dam share 50 percent breed composition. If individual heterosis for average daily gain was .2 pounds per day or 8 percent in a first cross, in a backcross yielding only 50 percent individual heterosis, the improvement in average daily gain would be expected to be 4 percent of the mean of the pure breeds.

Crossbreeding systems - A number of crossbreeding systems are used in swine production. They can be classified as rotational, terminal, and the combination rotaterminal systems. In general, rotational systems are easily managed and relatively inexpensive to operate. They suffer from less-than-maximum heterosis and no breed complementation. These systems are particularly well suited for medium- to small-sized operations.

Terminal systems require purchase of replacement females or their production in a separate component of the herd, either of which is relatively expensive. This is offset by the maximization of breed complementation and heterosis (individual and maternal). These systems are well suited to large operations of 100+ sows.

Rotaterminal crosses have some advantages of rotational and terminal systems. Replacement gilts are produced within a small component of the system. Breed complementation and individual heterosis are maximized in the terminal cross component. However, management of replacement female production and designing appropriate matings is complex in a rotaterminal crossbreeding system. More detail about each of these three systems follows.

Rotational systems - Traditionally, these systems have been used heavily in medium- to small-sized operations. In a rotational system, 2-4 lines of boars are rotated into the breeding herd, and replacement gilts are selected from among market hogs. Rotational system advantages are in easy management and relative low cost. Replacement females can be selected from among the market progeny with no special matings required. Production of replacement females on the farm reduces cost and the risk of disease introduction.

Unfortunately, rotational systems suffer two distinct disadvantages. All breeds that are incorporated into a system are used as sires; thus, no specialization of sire and dam lines is possible, and the system yields no advantage of breed complementation. Also, since breeds are used as sires on a rotating basis, the breed makeup of replacement females always shares a fraction of the breed of their mate, thus reducing heterosis.

Terminal systems - Terminal crossbreeding systems are currently very popular, especially in large commercial operations of 100+ sows. These systems are simple to manage since both replacement boars and gilts are purchased. These systems involve mating boars from a specific terminal line or a cross of two terminal lines to gilts from a specific maternal line or a cross of two maternal lines.

The boars and sows in a terminal crossbreeding system will always be from the same respective line. For example, in a three-breed terminal cross in which Duroc boars are mated to Yorkshire x Chester White sows, all boars will be Duroc and all sows will be Yorkshire x Chester White. All offspring are sold for slaughter.

Terminal system advantages include simple management, since any boar can be mated to any sow. Breed complementation is maximized since all sows can be from lines with excellent maternal characteristics and all boars from lines that are lean and efficient. Heterosis is also maximized in both the dam (if she is a line-cross) and the progeny.

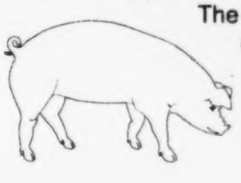
A disadvantage is that replacement females are purchased. Replacements can be costly, and there is risk of disease introduction into the breeding herd.

Combination rotaterminal systems - Rotaterminal systems involve a combination of the two previously described systems. Replacement gilts are produced in the herd and are of a rotation of two or more maternal type breeds. The females not needed for production of replacement females are mated to a terminal type boar, and all the progeny from this mating go to slaughter.

Rotaterminal crosses have some of the advantages of each system. Replacement females are produced from within the herd. Breed complementation and individual heterosis are maximized in the part of the herd involved in the terminal cross. Disadvantages include management complexity and less-than-maximum maternal heterosis.

Other Tools Used in Swine Selection

STAGES - For independent seed stock producers, an important breakthrough in evaluating genetic merit was the development of the Swine Testing and Genetic Evaluation System (STAGES) at Purdue University. The STAGES program is a computer package that evaluates expected progeny differences for traits of economic importance in swine production. The STAGES program operates through breed association offices. Performance records are sent to the associations for processing. The STAGES program estimates the genetic merit of animals relative to other animals in the breed. Other programs for evaluating genetic merit might also be available from state swine improvement organizations or for purchase from commercial companies.



Independent culling levels and selection indexes - In most selection programs, two or more traits must be considered simultaneously when making selection decisions. Two successful methods of simultaneously selecting for more than one trait are *independent culling levels* and *selection indexes*. Independent culling level refers to a method in which animals are culled if they perform below expectation for any trait considered important. The level of performance criteria must often be determined by experience.

An example of the use of independent culling levels for gilt selection might be to choose litter size, growth rate, and back-fat thickness are the traits of importance. Culling criteria might be set at litter size = 10, days to 230 pounds = 168, and back-fat thickness adjusted to 230 pounds = .85 inches. Gilts surpassing these criteria would then be examined for soundness. A small percentage in excess of the number needed for replacements would join the replacement pool.

Alternatively, a selection index that includes weightings for the three traits might be used. The appropriate weightings or multipliers have been determined for different conditions and are given in National Swine Improvement Federation materials; these should be available from a local extension specialist.

DNA testing - Direct evaluation of an animal's DNA might become a widely used method of evaluating genetic merit, although at present, its use is limited to a small number of traits that are influenced by single genes with large effect. In the future, DNA may be recognizable for many genes that have small influences on economically important traits. This technology is referred to as *marker-assisted selection*.

Anatomical defects of swine - Several physiological defects are occasionally observed in swine herds. One frequently discussed defect is porcine stress syndrome (PSS). It is a condition that can result in pigs with a recessive gene at a particular location on both copies of a chromosome pair. Porcine stress syndrome can be fatal to stressed pigs. In particular, it is likely to occur in finishing pigs and often is evident when loading and unloading. Signs of PSS include labored breathing, shaking, and a blotchy appearance on the skin. The gene that causes PSS also has an effect on animal performance, resulting in increased muscularity and possibly reduced reproductive performance.

Not all animals with the genes that cause PSS will show symptoms. A DNA blood test is now available that can tell whether animals carry 0, 1, or 2 copies of the gene that results in PSS. This test has been a major breakthrough because it is now possible to identify animals that carry a single copy of the gene but do not show symptoms of the condition. Porcine stress syndrome is often linked to pale, soft, exudative pork (PSE), which causes meat to be watery and chewy. However, there is no direct correspondence between PSS and PSE. Porcine stress syndrome results in only about one-third of PSE cases.

Other defects - Rectal prolapse, umbilical and scrotal hernias, splayleg, and inverted nipples are other defects that occur in a swine herd. Rectal prolapse happens when the rectum becomes loose from its supporting connective tissue and protrudes through the anus. Often, this condition is associated with estrogenic compounds in the feed, an inflammation of the lower gut, and excessive piling or coughing among pigs.

Hernias result when abdominal organs protrude through the umbilical ring.

Splayleg is a condition of newborn pigs in which the rear legs extend outward to the side of the body and the pig is unable to stand properly. This condition frequently results from the sow's intake of moldy feed.

Inverted nipples do not extend outward from the body, and when palpated, tend to contract inward. A poorly inherited genetic component is often involved in causing inverted nipples; however, nipples that appear inverted in replacement gilts can become normal at farrowing.

Susceptibility to these conditions can result from the combination of several genes, particularly when aggravated by infection or excessive pressure. None of these conditions, however, result from a single gene, as does PSS.

Genetics is usually the cause if a defect shows up in a particular sire's progeny across multiple litters, but not in progeny produced by other sires. If a genetic cause is indicated, it can be corrected by culling daughters of the suspect sire and by breeding herd females to a boar unrelated to the one that is suspect.

Summary

In this increasingly competitive age, it is important to utilize all selection tools available in the swine industry today. Careful research must be done to ensure that the best choice is made.

Credit

Swine Genetics Handbook. West Lafayette, IN: Cooperative Extension Service, Purdue University, 1988-1995.

Lasley, John. *Genetics of Livestock Improvement*. 4th ed. Indianapolis: Prentice-Hall, 1986.

Lesson 1: Importance of Reproduction in Livestock

How does livestock reproduction affect the average consumer? For producers to receive the optimum price for their products, they must improve the herd's quality through reproduction and genetics. This improvement influences the quality of products available in the store. In turn, consumers influence livestock quality through their buying power.

Careers Associated With Livestock Reproduction

There are many careers associated with livestock reproduction. Most of these occupations require an intense educational background with a strong science emphasis. This usually requires a baccalaureate college degree from a four-year institution, and some require additional educational experience.

Some of the careers associated with livestock reproduction are: veterinarian, breed association representative, breeding services technician, livestock scientist, Extension livestock specialist, sales representative, and livestock producer.

A veterinarian deals with a wide spectrum of livestock reproduction activities. Some of these activities are: AI programs, semen collecting, pregnancy testing, embryo transfer, cloning, and assisting with the birth process. Becoming a vet usually requires eight years of postsecondary education, in which the last four years are completed at specific institutions.

An occupation in a breed association is concerned with improving that particular breed through genetics. Breed associations compete with other associations to promote the superiority of their breed. This occupation usually requires four years of postsecondary education.

Breeding service companies, such as ABS, provide semen access and drugs associated with livestock reproduction. The educational requirement of breeding services is four years of postsecondary education.

Livestock scientists provide the latest research on livestock reproduction, such as genetic engineering, cloning, and embryo transfer. The educational requirement for this occupation is 7-8 years of postsecondary education.

An Extension livestock specialist provides information to the livestock producer on new and old methods and techniques in livestock reproduction. Extension specialists are available resources to any livestock producer in the U.S. The educational requirement for an Extension livestock specialist is usually at least four years of postsecondary education.

The main emphasis of a livestock producer is to produce quality livestock for his/her living. A livestock producer must have a strong experience background with livestock reproduction. Experience is more valuable than an educational background; however, gaining an educational background is becoming more and more valuable with all the new information bombarding the livestock industry.

A sales representative for livestock breeding products provides products used in purebred and commercial breeding programs. The educational requirement is usually four years of postsecondary education.

Economic Factors Associated With Reproduction

There many economically important reproductive traits that are influenced by inheritance. These traits determine profit or loss in a livestock operation.

Beef cattle - With beef, the first trait is calving interval. Cows which do not produce yearly calves are too costly to keep. Birth weight is an economic trait that is associated with calf survival rate. Low birth weight decreases the survival rate in calves.

Weaning weights are a good indication of milking ability and mothering ability. Gains before weaning are cheaper than after weaning, which result in increased profits for the producer. Maternal ability is important for calf survival and weaning weights.

Daily rate of gain becomes increasingly important in getting animals to market weight in a shorter period of time. Daily rate of gain is also highly correlated to efficiency gain. Pasture gain becomes extremely important when animals are raised on pastures, in backgrounding, and with cows on pasture.

Another economic trait influenced by livestock reproduction is efficiency of gain, which is the conversion of feed into muscling and rate of gain. More money can be made on animals that reach final feedlot weight at a faster rate. This weight is also influenced by birth weight, weaning weight, and rate of gain.

Conformation score is significant in relation to animal longevity (life span) and appearance. Finally, carcass traits measure the final product of the producer's efforts. Carcass traits are measured by the quality and quantity of the edible final product. More profit comes from a larger, quality carcass. Beef producers instill a breeding system that builds on these economic traits to improve their entire herd genetically.

Dairy cattle - In dairy, milk production is the essence of a dairy operation. The more milk that is produced, the more income received by the producer. Percent fat is considered icing on the cake; the higher the percentage of butterfat, the higher the price paid for a pound of milk. Percentage of protein in milk also increases the price paid for milk.

Soluble nitrogen-free extracts help animals take advantage of more nutrients in feed and convert nutrients into usable products. Feedlot gain is not as important in dairy cattle as it is in beef cattle, but it is vital for dairy steers on a feedlot.

Like beef cattle, stature becomes important to the longevity of animals. Stature is important in dairy cattle because of the length of time spent on hard surfaces such as concrete.

Legs and feet are strongly related to the animal's stature and are also influenced by reproduction. Correct legs and feet will influence the animal's production span.

To continue to produce milk, a dairy animal must have strong udder support. A strong udder will increase the longevity of the animal to continue to produce milk.

When considering economic traits, milking speed becomes important in a dairy operation. The quicker a cow milks, the quicker the milking procedure is completed, and the producer can move on to other projects.

Like other classes of livestock, birth weight is associated with survival rate and calving ease. Temperament becomes very important, especially in dairy cattle. An animal that becomes excited every time it enters the milking parlor will become extremely hard to milk and will be replaced soon.

As in any class of livestock, fertility is important. The longer it takes a female to become fertile, the longer it takes for that animal to come into her milking cycle; this is very costly for the producer. All dairy producers instill a breeding system that builds on these economic traits to improve their entire herd genetically.

Sheep - In sheep, multiple births are the first economic trait influenced by reproduction. Additional lambs produced by a single ewe will increase the amount of money that can be made by the producer. Like other classes of livestock, larger birth weights generally mean more vigorous lambs that have higher rates of gain.

Again, weaning weights reflect maternal ability and a cheaper rate of gain at weaning time. Rate of gain generally reflects milking ability of the mother and faster growth rate, which means more money in the pocket.

Type score in sheep determines market value and the ability to thrive under certain environmental conditions. Finish or condition at weaning is very important to the feeder lamb producer. The better the condition and finish at weaning weight, the better the price paid at market.

Wrinkles and skin folds become an economic factor because they determine shearing ease and wool fiber uniformity. Face covering determines the ease of grazing for animals. Because of the wool hanging in their eyes, wool-blinded animals have decreased grazing ability and require extra labor for trimming. Fleece weight largely decides the price received for wool. Like fleece weight, staple length influences the price received for wool because it measures the length of fibers.

Finally, carcass quality largely influences profit or loss for the mutton producer. All sheep producers instill a breeding system that builds on these economic traits to improve their entire flock genetically.

Swine - For swine, a litter size at birth is an important economic trait related to reproduction. A high pig average is a desirable economic trait. Litter size at weaning is just as important as litter size at birth. Litter size at weaning reflects maternal ability. Heavier pigs at birth have more vigor and an increased survival rate. Like other classes of livestock, litter weight at weaning is an important economic trait for a swine producer. Remember, it is cheaper to put on pounds from birth to weaning than on post-weaning pounds.

An economic trait that is important for any swine producer is daily rate of gain from weaning to market weight. The more efficient the hogs, the quicker they go to market, which lowers feed costs for the producer. Like daily rate of gain, efficiency of feed reflects the conversion rate of pounds of feed to pounds gained. Every swine producer understands that efficiency of feed is an important economic trait influenced by inheritance.

Hard surfaces found in confinement facilities are very hard on hogs' legs and feet. Conformation score becomes important to swine producers who raise hogs in confinement facilities.

Finally, carcass quality is important to every swine producer. Buyers pay more for a quality swine carcass.

Parts and Functions of the Male Reproductive System

The scrotum is a heat-regulating structure that provides the proper temperature for sperm production. Sperm cannot be produced at normal body temperatures. The scrotum's function is to lower the testes when cooling is needed and contract them when warmth is needed. For sperm production to occur, the testes must be 4-7 degrees Celsius lower than normal body temperature.

All classes of male livestock are born with two testes, unless an abnormality occurs. The testes produce sperm and secrete male sex hormones. The testes are made up of several thousand feet of very small, tangled tubules called seminiferous tubules. These tubules are the actual structures that produce sperm within the testes.

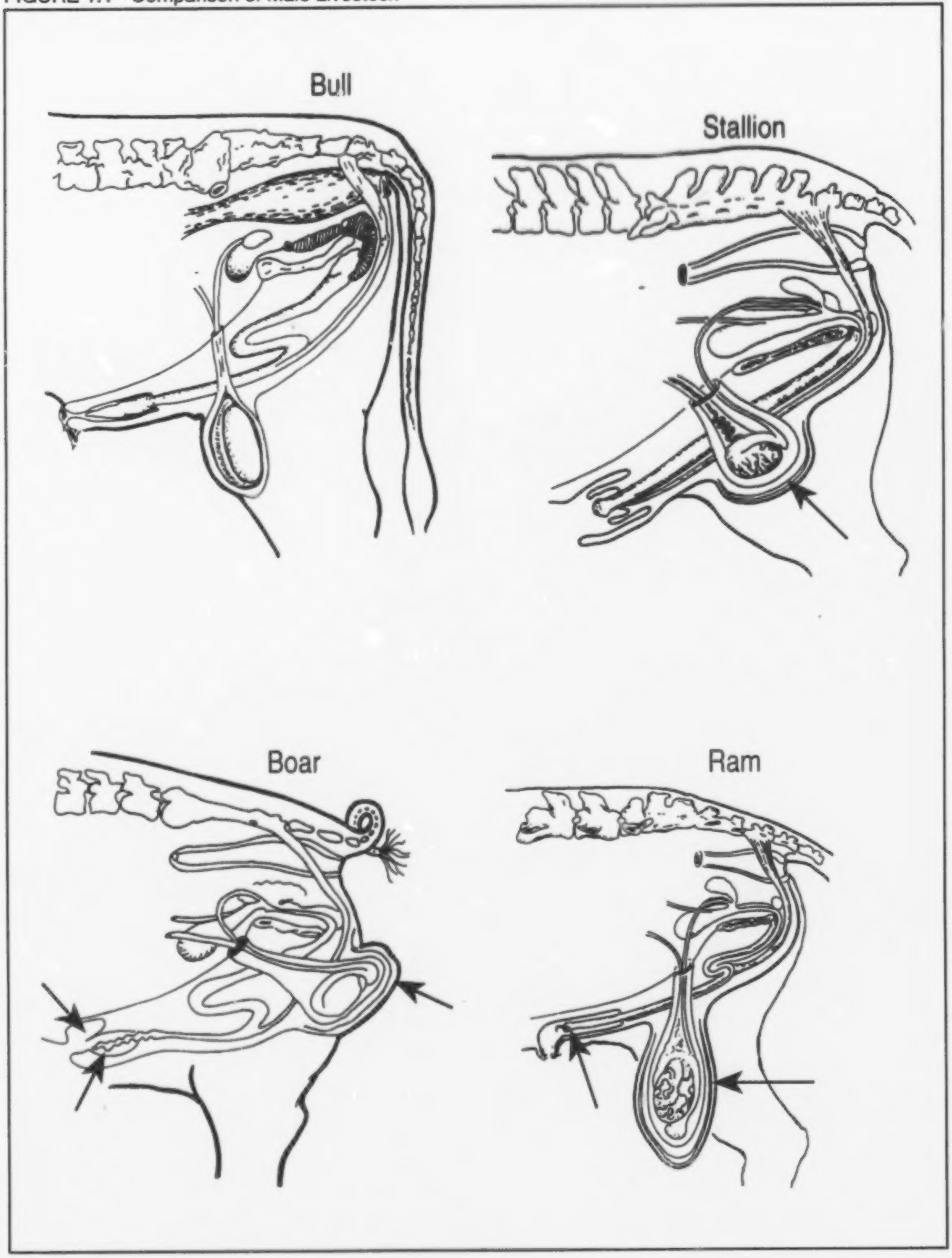
The epididymis is an elongated body close to the testes. It consists of three parts: the head, the body, and the tail. The epididymis has four functions: to store, mature, transport, and concentrate sperm. Sperm storage occurs in the tail of the epididymis. Sperm maturation is achieved through secretions from the epithelial cells. The epididymis transports sperm produced by the seminiferous tubules to the tail of the epididymis. Water absorption aids in this transportation.

The vas deferens transports sperm from the tail of the epididymis to the penis. The sperm passes by accessory glands like the seminal vesicles, prostate gland, and the Cowper's gland to produce the fluid called semen. Seminal vesicles are located posteriorly under the prostate gland and empty into the urethra. Secretions produced by the seminal vesicles make up 50 percent of the fluid in semen. This yellow fluid consists of high concentrations of proteins, potassium, citric acid, fructose, and several enzymes. It usually has a pH of 5.7-6.2.

Surrounding the urethra, the prostate gland's secretions pass into the urethra through small ducts along the urethra. Prostate secretions are similar to secretions produced by the Cowper's gland. Prostate secretions usually have a pH of 7.5-8.2.

The Cowper's gland is located above the urethra and near the rectum. The Cowper's gland is about the size of a walnut; like the prostate gland, it produces secretions to flush the urethra before mounting. The secretions are clear, watery, and

FIGURE 1.1 - Comparison of Male Livestock


Bull
Stallion
Boar
Ram

sperm-free in nature. These secretions have the same pH as those found in the prostate gland.

The urethra is a jointed canal used for both semen and urine transportation. The urethra uses the length of the penis to carry urine from the bladder, or semen from the accessory sex glands, to the head of the penis.

In a dual role, the penis excretes urine from the body or deposits semen into the reproductive tract of the female. The length of the penis begins at the bladder and accessory glands and ends at the free part located in the sheath. Blood is pumped into the chambers of the penis during sexual excitement, which causes the straightening of the sigmoid flexure. When the sigmoid flexure straightens, it causes an erection and aids copulation. After copulation, the sigmoid flexure contracts and the retractor muscle pulls the penis back into the sheath. The sheath is the protective opening where the retracted penis is kept in a fixed position when relaxed.

Differences in male reproductive systems - The ram's scrotum is shorter than the scrotum found on a bull. The ram's scrotum is also covered with wool. In a ram, the urethra opening extends out further than the head of the penis, which rotates and sprays semen during ejaculation. (See Figure 1.1.)

The boar's scrotum is located just below the rectum, not hanging from the bottom of the animal as in other species. In the boar, the free part of the penis is shaped like a corkscrew. The boar has a preputial pouch above the opening to the sheath, which is responsible for the strong sex odor in boars. This pouch contains a mixture of decomposing urine and macerated epithelial cells, which permeates their meat and gives it a bad taste. This is why boar carcasses are seldom used for human consumption.

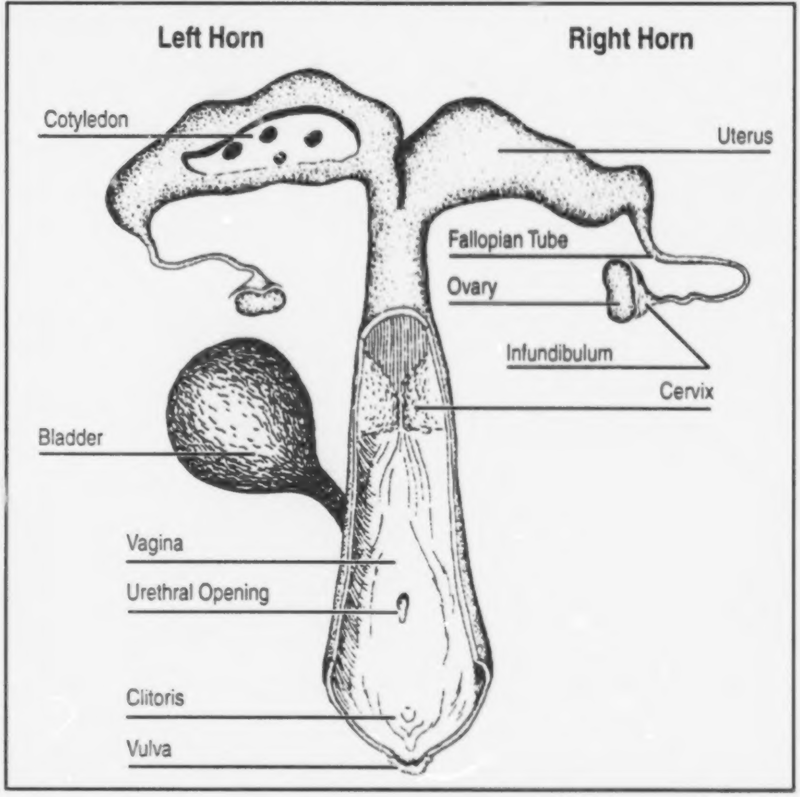
On a stallion, the scrotum is less pendulous than a bull's. In a relaxed state, the stallion's testes lie horizontally, but in an excited state, the testes become almost vertical in nature. A stallion is without a sigmoid flexure.

Parts and Functions of the Female Reproductive System

The bladder's sole function is to store urine in the female. The urethral opening is the bladder's opening into the reproductive tract. The vulva is the external opening of the urinary tract and the female reproductive tract. (See Figure 1.2.)

The ovary is the structure that produces the egg or ovum. The ovary is connected to the Fallopian

FIGURE 1.2 - Parts of a Cow's Reproductive Tract



tube by the infundibulum. Then, the Fallopian tube carries the egg or ovum from the ovary to the horn of the uterus.

Twelve hours after the estrous cycle is completed, the ovary releases the ovum or egg into the upper third of the Fallopian tube, where fertilization occurs if the egg unites with sperm. The fertilized egg empties from the Fallopian tube into the uterus, where the fetus begins to develop. The cotyledon is used as an attachment point for connecting the placenta to the uterus.

When fertilization occurs, the cervix acts as a plug for the uterus. Once the fertilized egg empties into the uterus, the cervix closes, completely sealing the uterine cavity from the vagina. This closure protects the fetus from bacterial and foreign invasions. The cervix liquifies shortly before the birth, allowing the fetus to be expelled from the uterus.

The vagina is the female organ where semen is deposited at copulation. Semen is deposited at different places, depending on the class of livestock and the copulation process. Semen can be deposited as far in as the uterus. Like the cervix, the vagina dilates during the birth process to allow the fetus to be born.

Located in the vulva, the clitoris is the sensory organ allowing the penetration of the male penis. This sensory organ allows copulation to occur and is stimulated during the estrous cycle.

Summary

A good knowledge of animal reproduction helps people in livestock production and related occupations understand the complexity of this process. Knowing economically important reproductive traits is a necessity for a person in this field.

Credits

Animal Breeding Unit (Ag Science Core Curriculum). University of Missouri-Columbia: Instructional Materials Laboratory, 1981.

Blakely, J.; D. Bade. *The Science of Animal Husbandry.* 6th ed. Englewood Cliffs, NJ: Prentice-Hall 1994.

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Hafez, E. S. E. *Reproduction in Farm Animals.* 6th ed. Philadelphia, PA: Lea & Febiger Publishing, 1993.

Lesson 2:
Reproductive Hormones

The reproductive system of livestock is highly influenced by certain hormones. Therefore, to better understand the reproductive system, it is important to know the reproductive hormones and their functions.

Female Reproductive Hormones

Estrogen - The ovaries produce estrogen, which signals the rest of the reproductive system to prepare for ovulation. Estrogen is responsible for female sex characteristics. It causes uterine growth and contractions, as well as mammary duct system growth.

Estrogen's main role is to control the estrous cycle. When heat signs are especially obvious, the blood has a high level of estrogen. As the hormone's level decreases in the bloodstream, heat signs also decrease.

Progesterone - Progesterone is produced by the corpus luteum. The corpus luteum is a scar-like structure produced immediately after ovulation by an increase in follicular cells from the cavity left by the vacated egg. Progesterone prepares the uterus for pregnancy by reducing uterine movement and promoting nurturing secretions. Progesterone also blocks the release of the follicle-stimulating hormone from the pituitary gland. If pregnancy does not occur, the corpus luteum regresses (returns to its original form) and stops progesterone production. Progesterone is responsible for blocking the estrous cycle. It also stimulates alveolar growth in the mammary glands.

Follicle-Stimulating Hormone (FSH) - FSH is produced by the anterior pituitary gland. FSH causes growth of the follicle (part of the ovary that contains a mature egg). FSH is produced midway between the heat periods.

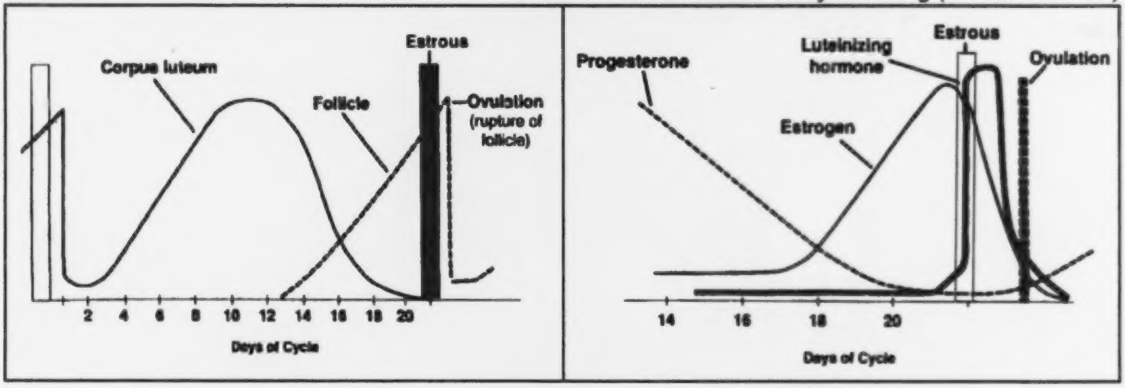
Luteinizing Hormone (LH) - When FSH production ceases, the anterior pituitary gland produces LH. LH travels to the ovary and causes the follicle to rupture, which causes the egg ovulation (release). After releasing the egg, the follicle collapses. LH continues to affect the ovary, and cells begin to grow in the void left by the ruptured follicle. The corpus luteum then takes the follicle's place, thus stimulating the production of progesterone.

Oxytocin - Oxytocin is produced by nerves in the brain and stored in the posterior pituitary gland. This hormone causes milk ejection and egg expulsion. It also causes uterine contractions. Oxytocin is often given to induce birth or to increase milk let-down in lactating mothers.

Relaxin - Relaxin is produced in the corpus luteum in most livestock, except for the mare, where it is produced by the placenta. This hormone causes the relaxation of ligaments and cartilage in the pelvis and dilation of the cervix, which assists in birth.

FIGURE 2.1 - Normal Estrous Cycle Development and Hormone Levels (Cattle)

Credit: *Livestock and Poultry Breeding (Student Manual)*



Prolactin - Prolactin is produced by the anterior pituitary gland. It initiates lactation and induces maternal behaviors.

Prostaglandin f-2-alpha - If fertilization does not occur, the uterine lining starts secreting the hormone prostaglandin. This hormone causes destruction of the corpus luteum, a reduction of progesterone secretion, and therefore an increase in FSH secretion. At this point, the estrous cycle begins again.

Male Reproductive Hormones

Testosterone - Testosterone is produced in the tissue of the testes. As the male matures, increased testosterone levels in the bloodstream trigger the development of the sex glands and secondary sex characteristics, including an aggressive nature and heavy muscling (especially around the neck and shoulders). Testosterone also controls the male's sex drive or libido. This hormone causes the maturation of sperm cells and the production of seminal plasma.

Follicle-Stimulating Hormone (FSH) - FSH is produced in the anterior pituitary gland. This hormone stimulates sperm production in the male (spermatogenesis).

Luteinizing Hormone (LH) - LH is also produced in the anterior pituitary gland. LH causes testosterone production in the tissues of the testes.

Summary

Hormones are chemical compounds that help regulate body functions. Hormones have a tremendous effect on the reproductive cycles of livestock. They control the development of sex characteristics, mating, and eventually fertilization. Therefore, hormones control the entire life cycle of livestock.

Credits

Agriscience 332: Animal Science (Student Reference). Texas A & M University: Instructional Materials Service, 1989.

Livestock and Poultry Breeding (Student Manual). Columbus, OH: Ohio Agricultural Education Curriculum Materials Service, 1989.

Gillespie, James R. *Modern Livestock and Poultry Production.* Albany, NY: Delmar Publishers, Inc., 1989.

Smith, Robert. *Animal Science 11 (Student Reference).* University of Missouri-Columbia: Animal Science Department, 1989.

Lesson 3:

Reproductive Cycles of Common Livestock

In humans, puberty occurs when male and female characteristics become more prominent than in the adolescent stage. Puberty begins with the release of hormones into the bloodstream. These hormones stimulate growth of the reproductive organs. Like humans, animals reach puberty in the same manner. Animals mature at a much faster rate than humans, however. Most production livestock species have reached puberty by the first year of life.

The Age of Puberty

In most classes of livestock, the initial sign of puberty in the female is the first estrous cycle. Puberty can be delayed by a poor nutritional diet or poor environmental conditions.

Cattle - A heifer's first estrous cycle can begin at 8-12 months old. The age difference depends on the breed, nutritional factors, and environmental factors. Smaller breeds usually mature faster than larger breeds.

The bull shows signs of puberty with the production of viable sperm and the desire to mount (about 8-12 months old). Both these indications are influenced by the hormone testosterone. The desire to mount can appear earlier in age, but usually viable sperm are not present.

Heifers are usually mated at 13-14 months or when they weigh 600-650 pounds. The age at which to breed is usually based on the producer's preference. The heifer's condition influences the time to breed. An older bull can service more females than a yearling bull.

Sheep - The first sign of puberty in the female is the estrous cycle, which can begin at 8-10 months. The beginning of the estrous cycle depends on the type of breed, nutritional requirements, and environmental conditions. In general, mutton breed ewes usually have their initial estrous cycle in the fall of their first year. Ewe lambs are somewhat slower reaching their sexual maturity than ram lambs.

The first signs of puberty in the ram are the production of viable sperm and the desire to mount. Testosterone released into the bloodstream influences sexual maturity in the male. These signs of puberty generally occur at 5-7 months.

Generally, young ewes are bred after they are 12 months old so that they lamb before 24 months of age. As in cattle, producer preference and the condition of ewe lambs determine the breeding schedule. Rams used for service before they are yearlings usually service a small number of females. After the rams have reached yearling age, they can service larger numbers of ewes.

Swine - A similarity between swine and other classes of livestock is that the first sign of puberty in the female is the first estrous cycle at 4-8 months of age. The wide age range depends on the type of breed, environmental conditions, and especially nutrition. All these differences can lead to a delay in puberty in swine. Nutrition is important in swine sexual maturity. If gilts receive a poor nutritional diet, puberty can be delayed dramatically. Gilts should reach 180 lbs. before 8 months of age. Most gilts do not begin their first estrous cycle until they weigh 180 pounds or more.

The first signs of puberty in the boar are the production of viable sperm and the desire to mount. Again, the desire to mount usually comes before the production of viable sperm. The first signs of puberty generally begin at 4-8 months. In general, boars reach their sexual maturity later than gilts. Gilts are usually bred to farrow at 11-12 months. In swine, breeding gilts largely depends on development, not age. A general rule is to breed gilts when they reach a weight of 225 lbs., instead of when they reach a certain age. Boars can begin service at 8-12 months. Younger boars service a smaller number of females in the earlier stages of their sexual maturity.

Horses - The ages of sexual maturity are very similar in horses. Both the male and female reach puberty at 12-15 months. As in other classes of livestock, the first signs of puberty in horses are the first estrous cycle and the production of viable sperm with the desire to mount.

Mares are bred based on their maturity level. Well-developed mares have been bred as early as 2 years old to foal when they are 3 years old. The best time to breed mares is when they are 3 years old so they foal when they are 4 years old. Stallions are ready for service when they have reached sexual maturity.

Estrous Cycle

Before puberty occurs, the female reproductive tract and ovaries grow slowly and show no functional activity. The growth of the reproductive tract seems to parallel the increase in body weight as the animal gets older. As puberty nears, the anterior pituitary gland releases FSH (follicle-stimulating hormones) into the bloodstream. FSH stimulates follicle growth in the ovary. As follicle growth occurs, ovarian weight increases and estrogen (a female sex hormone) is released. This release is triggered by a hormone called LH (luteinizing hormone), which is also produced by the anterior pituitary gland. The LH ruptures the follicle and releases the egg, which is called ovulation. Once this has occurred, the animal has reached puberty.

Puberty is reached at different ages, depending on the species. The estrous cycle or heat period begins when the female is willing to accept the male for mating. The cycle begins with release of estrogen from the ovaries, and the egg is ovulated. The length of the heat period, distance between heat periods, and release of the egg are different in each class of livestock. Table 3.1 shows the differences for each class of livestock.

Outward signs of heat - Successful, practical artificial insemination requires that a person's judgment be substituted for a sire's instinct. This is difficult, but not impossible if one is diligent. Similar conditions to some of those described below for finding cows in heat are often observed in other classes of livestock.

Cows in heat are affected by a sudden, high-level presence of the female or "heat" hormone (estrogen). The egg-containing follicle which produces the hormone is at the height of its growth.

The cow's nervous system is greatly affected; she is excitable and may bawl excessively. She is restless and often walks the fences. The producer who knows the cows well can often recognize heat by the alert, bright-eyed, nervous appearance shown by cows during this period.

Cows in heat attempt to ride other cows and stand to be mounted by other cows. Under natural conditions, they would stand and accept service by a bull. Standing is the only reliable, practical test for heat. When a cow stands, she is in heat and is ready for service.

Ruffled hair over the tail head suggests that a cow has recently been ridden; she may or may not have been in heat. Many heifers and cows in heat flatten themselves down in the loin region. This presents a "sway back" and "high tail head" appearance.

The sex hormone from the ovary also has an effect upon the genital organs. Genital mucous may flow from the vulva in long strings. Wet mucous smears are often seen on the buttocks, over the pin bones and under the tail. Also, the

TABLE 3.1 - Differences in Estrous Cycles

Type of stock	*Length of heat period*		*Interval of heat period*		*When egg is released*
	Range	*Average*	*Range*	*Average*	*Time*
Cattle	6-30 hrs.	16-20 hrs.	19-23 days	21 days	12 hrs. after estrous is completed
Sheep	20-42 hrs.	30 hrs.	14-20 days	16-17 days	24-30 hrs. after estrous cycle is completed
Swine	1-5 days	2-3 days	18-24 days	21 days	36-40 hrs. after onset of heat
Horses	2-10 days	4-6 days	10-37 days	21 days	In latter part of the estrous cycle

vulva of a cow in heat appears somewhat swollen.

On the second or third day after heat (or earlier), bloody mucous passes from the cow's vulva. This may be smeared on the buttocks, on the tail, or in a pool behind the cow after lying down. Bleeding from the cow means that she has been in heat (ovulated) 2-3 days before.

To ensure accurate results for an artificial breeding program, check for heat at least twice each day.

Spermatogenesis in Livestock

Spermatogenesis is the production of sperm within the seminiferous tubules in the male testes. This process occurs through meiosis, mitosis, and metamorphosis. Spermatogenesis starts with spermatogonia, which carry both sets of chromosomes (XY). Spermatogonia are sex cells in the form of immature sperm. Spermatogonia become mature sperm through spermatogenesis.

Mitosis is a form of cell division in which one cell divides into two separate cells, both containing two complete sets of chromosomes. In meiosis, sex cells divide and split the chromosome number in half. The spermatogonia have two X chromosomes and two Y chromosomes. Spermatogonia first divide during mitosis and make an identical cell with two X chromosomes and two Y chromosomes. A cell having two X chromosomes and two Y chromosomes is called a diploid. In the first meiotic division, the diploid is split in half, creating a haploid. A haploid has only one X chromosome and one Y chromosome.

The spermatogonium goes through a second meiotic division where the first haploid divides into a second haploid. Once this division occurs, the new haploid is left with either an X chromosome or a Y chromosome. The new haploid has either an X chromosome or a Y chromosome, not both. This is important because it determines the sex of the offspring.

Before the second haploid becomes a mature sperm, it must go through a metamorphosis (change). Then, the haploid receives a head and a tail to move through the female reproductive tract. Once this metamorphosis occurs, the haploid is a mature sperm. An X chromosome sperm that reaches the egg first determines a female offspring, while a Y chromosome sperm determines a male offspring. The whole process of spermatogenesis takes about 46-49 days to occur.

Gestation Lengths

Gestation or pregnancy period is the length of time between fertilization and the birth of the offspring (parturition). To understand gestation, begin with the ruptured follicle that released the egg. This ruptured follicle develops into an endocrine gland called the corpus luteum. The endocrine gland produces hormones for the reproductive system, while the corpus luteum produces a hormone called progesterone, which maintains pregnancy in livestock.

Once the egg is fertilized, it floats freely in the uterus for a short time. Then, the fertilized egg begins development of the placenta. The placenta is attached to the uterus by the cotyledons, which hold the placenta in place for the remainder of the gestation period. Gestation lengths vary from one class of livestock to another. Table 3.2 shows the differences of gestation lengths in each class of livestock.

TABLE 3.2 - Gestation Length

Livestock class	*Range (days)*	*Average (days)*
Cattle	240-330	283
Swine	111-115	114
Sheep	144-152	148
Horses	315-350	336

Summary

It is especially vital for a livestock producer to understand the reproductive cycles of livestock. This understanding helps in AI programs, hand or pasture mating, determining the number of females per male, the age at which to breed young stock, and record keeping.

Credits

The Merck Veterinary Manual. 6th ed. Rahway, NJ: Merck & Co., Inc., 1986.

Blakely, J.; D. Bade. *The Science of Animal Husbandry.* 6th ed. Reston, VA: Reston Publishing Company, 1994.

Campbell, J.; J. Lasley. *The Science of Animals that Serve Mankind.* New York: McGraw-Hill Book Company, 1969.

Ensminger, M. E. *Animal Science Digest.* Danville, IL: Interstate Publishers Inc., 1991.

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Lesson 4:
Fetal Developmental Stages

The livestock industry relies on the production of quality animals to ensure a quality product for the consumer. The production of such animals begins with proper care of the developing fetus and its mother. Understanding developmental stages of livestock enables the producer to ensure the delivery of healthy young.

TABLE 4.1 - Timetable of Calf Development

Time (days)	Development
0	**First trimester** Fertilization in oviduct
4	Embryo (in eight- to 16-cell stage) reaches uterus.
8-11	Embryo transfer possible
12	Embryo forms weak attachment to uterine wall.
18	Amnion encloses embryo.
21	Heart begins to beat; reproductive tract begins to develop.
23	Head region is recognizable.
25	Forelimb buds appear.
30	First placental plates appear.
33	Fragile cotyledonary attachment forms.
37	Facial features appear.
46	Developing animal is now a fetus.
60	Eyelids can close.
100	**Second trimester** Horn pits appear.
110	Tooth development begins.
230	**Third trimester** Hair covers the body.
283	Birth

Developmental Stages of the Livestock Fetus

Animal life begins as a single cell (the fertilized egg). Through the processes of cell division, the cell multiplies and develops into a mature animal. Growth includes all of the physiological processes that allow the fertilized egg to develop into a many-celled animal.

Growth - Animal growth occurs because of an increase in both the size and number of body cells. The increase in the number of cells is called hyperplasia, while the increase in size of cells is hypertrophy.

During embryonic growth, all cells increase in size and number. However, in the adult animal, there are three different types of cells. Permanent cells, which include muscle and nerve cells, stop dividing or increasing in number early in prenatal life. Stable cells continue to increase in number and size throughout most of the postnatal growth stage and until the animal reaches maturity.

Prenatal growth - Growth/development before birth or hatching is one of two types of growth in livestock. This period involves the time between the fertilization of the ovum by the sperm (the formation of a zygote) and birth. The embryonic growth period includes early stages of prenatal growth and development. After fertilization, the zygote begins as one cell that contains chromosome pairs, one each from the mother and father. The zygote's single cell then begins a series of divisions into two cells, then four, then eight, etc. The cell division rate varies with different species of animals.

In the first stages of its life, the newly fertilized egg free-floats in its mother's reproductive tract. This embryo spends the first few days traveling in the oviduct toward the uterus. By the time it reaches the uterus, 16 or more cell divisions have taken place within the cell wall of the egg. Also, the hormone progesterone has prepared the uterus to care for the new animal. The egg's cytoplasm provides the necessary energy for cell division until the egg reaches the uterus.

After reaching the uterus, the egg continues to free-float and absorb nourishment from fluids in the uterus. This free-floating period lasts as long

406

as 30 days in the dairy cow and the mare, but is somewhat shorter in other mammalian livestock.

During this time, the embryo surrounds itself with a set of membranes. These membranes form a sac of fluid to keep the embryo moist and act as a shock absorber. These extra membranes and fluid (known as the placenta or afterbirth) attach to the rich uterine lining.

In hogs, the entire placenta attaches to the entire surface of the uterus. In sheep, horses, and cattle, there are cotyledons (button-like spots on the placenta) that attach to caruncles (spots) on the uterus. These points of attachment, along with arteries and veins in the umbilical cord, provide the calf with nourishment from the mother and waste disposal. Until birth, the embryo has its own blood circulation system plus the external (mother's) system, which passes through the umbilical cord.

Swine also have another reproductive characteristic that is unique compared to cattle, sheep, and horses. Swine are polytocous (litter bearing) animals producing multiple ova, which can all be fertilized to produce multiple births. It is not unusual for sows to ovulate 15-20 ova during an estrous period. This is the main reason why the entire placenta is attached to the entire surface of the uterus in swine.

Morphogenesis - The cells in the developing embryo go through a process of differentiation in which the cells organize into specific structures. This differentiation of cells into organs and tissues with a specific purpose is called morphogenesis. It begins with the cells dividing into three basic layers: the ectoderm (outer) layer, the mesoderm or middle layer, and the endoderm (inner) layer.

TABLE 4.2 - Timetable of Chick Development

Time (days)	Development
3	Blood circulation between embryo and yolk is established.
5	Sex can be determined.
8	General outline is recognizable.
8-9	Lungs, nervous, muscular, and sensory systems are in place.
10-11	Embryo is covered with down and first feathers.
21	Hatching occurs.

The ectoderm develops into the brain and other parts of the central nervous system, skin, hair, wool, hooves, and certain endocrine glands. The mesoderm develops into both voluntary and involuntary muscle tissue; the heart and other parts of the circulatory system; and connective tissue, such as bone, cartilage, ligaments, and tendons. The endoderm develops into the liver, digestive system, and other endocrine glands.

Body organs and tissues are formed in a specific sequence. For example, the head forms before the tail, and the beginning of the spinal chord forms before other organs. This process continues until all body organs and tissues are formed.

Highly differentiated cells, such as the brain, cannot be replaced if destroyed after the original number is fixed during the fetal stage (second stage of prenatal growth and development). Therefore, seriously damaged nerve cells are not replaced and usually remain damaged. Muscle cell numbers are also fixed during the fetal stage and increase only in size after birth. Bone tissue grows both before and after birth.

The rate of prenatal growth in livestock varies among species. For example, the length of gestation in pigs is 111-115 days, while in horses it is 315-350 days. Although the rate of prenatal growth varies, most livestock are born with a fairly equal degree of maturity.

Development of Embryo During Incubation

In birds, the process of incubation (causing something to develop or take form) corresponds to gestation in mammals.

Terminology - The amnion is the sac that surrounds the embryo. The chorion is the lining between the egg shell and the internal portion of the egg. Allantois refers to the part of an egg that stores excretory wastes; it fills the space between the amnion and the chorion.

Incubation - When fertilization occurs in poultry, the embryo begins development around a well-defined germinal disk. This area is clearly visible to the naked eye when a freshly laid, fertilized egg is broken. Within 48 hours after fertilization, a chick embryo establishes an intricate blood circulation system between itself and the life-sustaining yolk. (See Table 4.2.) Since there is no placenta, as in mammals, the poultry embryo has to develop on this circulation network to provide nutrients and remove waste products.

By the end of the third day, the embryo has a full set of membranes. The allantois, which stores excretory wastes, fills the space between the amnion and the chorion. Later, the allantois merges with the chorion to form the chorio-allantois, which expands and contacts the shell membrane. The chorio-allantois serves as the respiratory organ for the developing embryo until the pulmonary organ takes over about 24 hours after hatching. The shell and the membranes also protect the developing embryo from harmful microorganisms or molds.

As in mammals, the embryo floats within fluid in the amniotic cavity. The developing embryo is protected by this floating movement, and it must continue until the last 3-4 days before hatching. Without this movement, malformations can occur that endanger the life of the newly hatched chick. In an incubator, the egg must be turned several times a day to prevent adhering of the embryo to the chorio-allantois membrane. Under natural conditions, the hen instinctively shifts the egg several times a day.

Physical factors - Several physical factors are critical for adequate levels of egg incubation and hatching.

1. Temperature - To have most of the chick embryos survive, store the eggs for a maximum of seven days at 60°F outside the incubator. This allows for development processes to continue without adverse effects after the eggs are placed in the incubator. With some minor differences between breeds, a temperature range of 98-104°F within the incubator is best.
2. Humidity - Since the egg is approximately 70 percent water, it is important to maintain a certain humidity level to prevent water loss. Pre-incubation storage of hatching eggs should be at 85 percent relative humidity; during incubation, store eggs at 60-65 percent humidity. This water allows for excretion of the embryo's metabolic wastes and serves as a heat regulator, much like a car radiator transfers heat through water.
3. Air velocity - Although the rate of moving air in an incubator does not appear to have much influence on hatchability, a constant supply of fresh air is necessary for the developing embryo.
4. Energy supply - The egg represents a highly concentrated form of energy provided by the hen. This stored energy is extremely important for the developing embryo during incubation *and* in later stages. Embryo development uses 25 percent of the egg's energy; the rest is incorporated into the developing chick.

Nutritional Requirements During Pregnancy and Lactation

Cattle - The period during which the calf crop is affected most by nutrition extends from 30 days before calving until 70 days after calving. The nutritional needs of nursing cows are higher and more critical than those of pregnant cows. After a cow has calved, her energy needs jump about 50 percent; her protein needs double; her calcium and phosphorus needs triple. Compared to during pregnancy, she needs approximately 50 percent more feed for milk production.

During the last trimester, the nutritional requirements are higher than in an open female because of the requirements of the growing fetus.

Sheep and goats - In general, feeding a suitable, well-balanced ration with necessary minerals and vitamins will ensure a strong, healthy lamb crop. During the last 4-5 weeks before lambing, the fetus develops rapidly and demands on the ewe are heavy. Ewes should be fed 0.5-1.0 pounds of grain per head daily during this time.

Following lambing, the feed allowance of the ewe should be increased according to her capacity and needs. Though varying somewhat with size and condition of the ewe (and whether she is raising twins or a single lamb), an adequate ration can consist of 4 pounds of high-quality alfalfa hay plus 1-2 pounds of grain daily.

Swine - About two-thirds of the fetal growth occurs in the last month. During gestation, it is important that body reserves be stored for lactation. Feed should be increased to 4-5 pounds daily. However, sows should not be overfed because fat sows have farrowing difficulties. Four to five days before farrowing, it is a good practice to decrease feed intake and feed a bulky, laxative feed.

Nutrient requirements of a lactating sow are more rigorous than requirements during gestation. The lactating sow should be fed 2.5-4.5 pounds daily for each 100 pounds of body weight.

Summary

Although gestation periods of various species of livestock differ, the stages of fetal growth and the effects of gestation on the mother are very similar. The growth of the fetus is just more rapid when the length of gestation is shorter. To ensure a safe pregnancy and healthy offspring, it is important to make management changes that relieve stresses placed on the mother during gestation.

Credits

Agriscience 332: Animal Science (Student Reference). Texas A & M University: Instructional Materials Service, 1989.

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Gillespie, James R. *Modern Livestock and Poultry Production.* Albany, NY: Delmar Publishers, Inc., 1989.

Lesson 5:
Effects of the Environment on Reproduction

Plant *and* animal growth are affected by the photo period, environmental conditions, and fertilization requirements. Both plants and animals are affected by the length of daylight hours. Like plants, animals that do not receive the correct amount of nutrients have reproductive (growth) problems. Like plants, livestock reproductive difficulties become more apparent during extreme environmental conditions. If animals cycle naturally and receive adequate nutrition and temperature, they will also reproduce abundantly.

Effects of Nutrition and Body Condition

Nutritional diet - Nutrition is related to several reproductive difficulties in female livestock. These difficulties seem more prominent in younger females than mature females. Older females have built up reserves within their bodies to pull from, but younger females do not.

Longer breeding and calving seasons can occur from poor nutritional diets. Because of deficiencies in their diet, a smaller percentage of females come into their heat period in the first 21 days after calving. Frequently, nutrient-deficient females will be less synchronized in their heats. This disturbance could result in a longer breeding and calving season. A low percentage of females conceive on the first service by the sire. Nutrient-deficient females have lower conception rates on the first estrous cycle.

Worse yet, poor nutrition can cause more calving deaths at birth (parturition) and in the first two weeks after birth, which results in extreme losses for that year. Since all these difficulties can be prevented through a proper nutritional diet, producers can control their own destiny.

Livestock producers must be aware of nutritional requirements for females during lactation, gestation, and the pre-breeding period. Most reproductive failures are caused by deficiencies in one or more nutrients during the 100-day period before birth and the days immediately following birth. Critical nutritional deficiencies during this 100-day period will determine the conception rate and calving difficulties during the next breeding season.

Flushing is a nutritional technique used by swine and sheep producers to prepare breeding stock for the breeding season. Flushing keeps sows and ewes on a full feed ration to allow the body and reproductive tract to build back up before the next breeding. If this method is used, reproductive problems associated with nutrition will be reduced.

Energy is more important than protein when it comes to reducing reproductive problems. Livestock receiving inadequate levels of energy have more reproductive difficulties. Diets containing low levels of phosphorus have a reduction in the calf crop. Low phosphorus diets usually occur in the range land in the western states, where forages have lower levels of phosphorus. Heifers on a dry forage diet benefit from supplements of vitamin A.

The amount and type of feedstuffs fed before and after calving determine conception rate and proper timing of heat periods for the next breeding season. Feed requirements increase after calving, so feeding allowances must parallel this need. If not met, the female will have severe weight loss, which will delay the heat cycle and decrease conception rates.

Body condition - The female's condition also affects reproductive difficulties. During gestation, the female's condition determines reproductive difficulties for the next breeding season. An average conditioned cow should have a minimum gain of 100 lbs. during gestation. After calving, an average conditioned cow should gain $^1/_2$ to $^3/_4$ lb. daily to build up reserves for the next breeding season. A cow in thin condition should also have a 100 lb. minimum gain during gestation, but it should gain $1^1/_2$ to 2 lbs. daily after calving to build up reserves for next breeding season.

In reality, the condition of the female body during gestation and after birth applies to all classes of livestock. Adequate gains can be achieved through a proper diet and quality feedstuffs. A proper diet during these periods will produce healthier offspring, lower mortality rates, quicker breed back, and longer female productive life. The principles of nutrition apply to all classes of livestock; only the numbers will be different.

In females that have not reached puberty yet (prepubertal), a restricted or nutrient-lacking diet can delay puberty or cause hypoplasia. Hypoplasia is the defective or incomplete development of reproductive organs; it is usually the reason reproductive organs remain below normal size. Nutritional disorders can be detected in females by the lack of an estrous cycle. A proper diet can solve prepubertal disorders if the problem is caught in time.

Effects on sires - Nutritional deficiencies also affect the reproductive efficiency of the male. Younger sires are affected more than more mature sires. Older sires can go many months on a poor or deficient diet without reducing sperm numbers. These mature sires use body reserves to maintain proper sperm production.

A poor nutritional diet can delay puberty and can be fatal if the nutrient deficiency is extreme enough. A nutritional deficiency in younger sires can cause irreparable damage over prolonged periods of time. This damage results in reduced testes size, low sperm production, and sperm replenishment.

Effects of the Photo Period

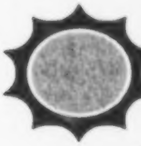


Photo period refers to the length of daylight. Corn, for example, needs a certain number of daylight hours to grow normally. Like plants, animals' reproductive cycles are influenced by daylight. Imported livestock breeds had to adjust to new environments, as did their reproductive cycles. Sometimes, these new breeds never adjusted to the new environment and they could not reproduce in this country. All classes of livestock are influenced by the photo period, although some are affected more than others.

Beef - Cattle are considered continuous breeders. Most beef producers aim for calving during September, October, and November, so the breeding season is during the months of January, February, and March.

Hogs - Swine are also continuous breeders. For this reason, most confinement pork producers plan breeding systems to keep their farrowing houses full year-round. For producers farrowing twice a year, breeding systems are more influenced by heat, funds available, and available feeds, not by photo period. Feed costs aren't significant in breeding swine since they are continually fed.

Horses - Sometimes, horses are considered continuous breeders. The breed usually has a greater influence on the reproductive cycle than the photo period. Since most equine breeds originated overseas, environmental conditions influence the timing of the reproductive cycle. Horses tend to show more sexual activity during the spring months.

Sheep - Although not considered continuous breeders, some sheep breeds can produce more than one lamb crop per year. Generally, sheep have a set breeding season stimulated by the photo period. Estrous cycles in sheep usually begin in September and end in March. The Dorset breed has the longest breeding season (June through April). If managed correctly, Dorsets can have two lambing seasons. Sheep are heavily influenced by the shortening of day hours.

Poultry - The early ancestors of poultry only laid eggs in the spring months. Through selection and improved management techniques, poultry now lay eggs continuously. Photo period has the greatest influence on poultry than on any class of livestock because the bird's eye is sensitive to light intensity. The optic nerve is responsible for detecting light intensity. When light intensity increases, activity in the pituitary gland increases. This pituitary gland activity continues hormone production, which stimulates the reproductive cycle. Continuous light in hen houses is the sole reason for continual laying by hens.

Temperature's Effects

Females - Environmental temperatures affect the reproductive cycle in livestock in many ways. Heat stress causes several problems in the female reproductive cycle. Extreme heat can delay the estrous cycle in many classes of livestock, especially in sheep. Remember, most sheep have a limited breeding season. Sheep do not begin showing signs of heat until late summer and early fall. Ewe lambs show the first signs of puberty in the fall of their first year.

Extreme heat influences offspring weights at birth by causing the female to expel more energy to cool her body than she provides to the offspring. Also, extreme heat causes a loss of appetite in animals, which decreases the amount of feed intake. This reduced feed intake lowers the amount of nutrients supplied to the offspring.

During the last trimester, extreme heat conditions can be detrimental. Extreme heat conditions contribute to abortions, fetal deaths, low birth weights and litter sizes, and abnormalities in offspring. The size of the placenta is reduced under extreme heat conditions, which can cause birthing difficulties.

Extremely cold temperatures usually do not have as much impact on reproduction as extreme heat. When extremely cold conditions do arise, the only factor that usually develops is a lower birth weight, since the female uses more energy to control body temperatures than it contributes to the offspring.

Males - The male's reproductive ability is affected by environmental conditions to a smaller degree. The production of testosterone is not influenced by extreme environmental conditions, but there can be some fluctuations in sperm production and abnormalities due to extreme heat periods.

There are seasonal variations in sperm production in males, but they have little effect on the reproductive efficiency of sires like extreme heat conditions do. The number of females serviced during extreme heat conditions is reduced because sires become exhausted more quickly. The testosterone levels are there, but the desire to mate is greatly reduced because of the extreme heat conditions.

Extremely cold temperatures do not have an affect on male reproduction because breeding seasons usually do not occur during these months.

Summary

For people associated with livestock production, it is vital to have a solid knowledge base of factors influencing the reproductive cycle. One must produce the greatest number of offspring to sustain a profit in the operation. Knowing that photo period, nutrition, and environmental conditions influence livestock reproduction will greatly improve monetary success for a producer.

Credits

Campbell, J., and J. Lasley. *The Science of Animals that Serve Mankind.* 3rd ed. New York: McGraw-Hill Book Co., 1985.

Ensminger, M. E. *Animal Science Digest.* Danville, IL: Interstate Publishers Inc., 1991.

Hafez, E. S. E. *Reproduction in Farm Animals.* 2nd ed. Philadelphia, PA: Lea & Febiger Publishing, 1968.

Lesson 6:
Management and Technology in Reproduction

The advancement of the livestock industry is due largely to the great strides made in improving the management and technology available in reproduction. Understanding these techniques and their effects greatly increases the success of livestock producers.

Artificial Insemination

Artificial insemination (AI) is the introduction of male reproductive cells (sperm) into the reproductive tract of a female by artificial means. The origin of AI is unclear, but an Arabian legend dating to 1322 maintains that the method was first used by a chieftain who had stolen the "seed" of an enemy's stallion to deposit into his own mare.

The first scientific research about AI of domestic animals was conducted on dogs by the Italian physiologist, Lazarro Spallanzani, in 1780. By the late 1800s, American veterinarians used it to get mares in foal that consistently did not settle by natural methods. AI has been in practical use successfully in the U.S. since the 1950s. In 1988, more than 65 percent of the nation's dairy cattle were artificially inseminated. AI is becoming increasingly popular in other classes of livestock, as well.

Benefits from AI - There are several advantages of using artificial insemination.

1. Through the use of AI, many more animals are bred to superior males selected on the basis of similar traits. These traits are often economically important or considered to be aesthetically pleasing. This provides greater uniformity in a breeding program.
2. With reasonably priced semen, the value of progeny produced exceeds the costs of semen and service. The offspring of outstanding sires are usually higher and more efficient producers--more profitable than other offspring.
3. It helps control disease. AI is a valuable tool in preventing and controlling the spread of venereal diseases. Also, reproductive problems in females are more easily detected.
4. AI improves herd records. The sires and breeding dates of each offspring are known. Thus, improved culling and management result from closer herd records and observations.
5. AI allows the development of genetically superior animals in a more timely manner. For example, in the cattle industry, the semen from a superior bull can be used through AI to service as many as 20,000 cows per year. Using natural service, this same bull would only be able to service approximately 60 cows per year.

Limitations of AI - Although there are many advantages to using AI, there are also some limitations.

1. Successful AI requires a skilled and conscientious technician. Adequate training is a must for any person performing this technique.
2. Just as superior genetics are passed to the next generation in a more timely manner, inferior genetic traits are perpetuated, as well. Often, selection *for* one trait can lead to selection *against* another.
3. There is some potential for abuse (e.g., improperly labeled semen).
4. AI requires more time and management knowledge. Proper heat detection of the female takes a great deal of time and knowledge. Also, because of the extra handling for palpation and insemination of each individual, extra labor and facilities are needed.

Semen collection - The most popular means of semen collection is through the use of an artificial vagina (AV). An AV is constructed to mimic natural copulation. It consists of an outer tube with a thin rubber lining. Water that is warmed to body temperature is used to fill the space between the lining and the outer tube. The liner is often lubricated, and one end of the AV is left open for entry of the penis. The other end has a small collection vesicle, usually a test tube, for the ejaculated semen.

Most sires can be trained to use cows, steers, or dummy mounts. The artificial vagina is forced over the erect penis when it tries to penetrate the dummy (or other mount). When filled, the test tube is removed and taken to a processing lab, where the semen is processed.

Electrical stimulation in conjunction with the artificial vagina is the second most common way to collect semen. The electro-ejaculator produces an electrical impulse to stimulate the nervous system, causing erection and ejaculation. Electrodes are placed in the bull's rectum, and low-power stimulations are given until semen is produced. This method is generally used to obtain semen samples for fertility testing or when a mounting dummy is not available.

Semen testing - Semen density is tested to estimate the number of sperm in the semen. Next, the semen is examined under a microscope. A drop of fresh semen is placed on a glass slide. The observer notes what percentage of the sperm move. If 80 percent or more of the sperm move, the "percent motility" is excellent; 70 percent is good; 50-60 percent is fair. Rapid forward movement is desirable.

Extending semen - Millions of sperm are ejaculated by the male at the time of mating. In natural mating, all these sperm are used to breed one female, although only one sperm of the millions fertilizes the egg. With AI, a male's ejaculation can be extended or diluted so that many more females can be bred with it. This is accomplished by adding materials to the semen that help keep it alive and give the sample more volume.

See Table 6.1 for some common extenders and the classes of livestock for which they are used.

TABLE 6.1 - Semen Extenders

Type of diluent	Animals used for
Egg-yolk citrate	Bull, ram
Egg-yolk phosphate	Bull, ram, stallion
Homogenized milk	Bull, ram, boar
Glycine-containing diluents	Boar

Antibacterial agents are added to the extenders to help control bacterial growth. To keep sperm alive, it is important that the extenders be added a few minutes after the semen is collected from the male. It is also important that sperm never be cooled suddenly. Thus, the semen and extender should always be near the same temperature.

Undiluted semen will not live much longer than 24 hours at room temperature. By adding diluents and slowly cooling the semen to refrigerator temperature (41°F), the sperm can be kept fertile for nearly a week.

Storage of semen - After special treatment of semen with extenders, the sperm can withstand freezing to extremely low temperatures. Bull semen is often stored frozen, while boar semen does not withstand freezing well and is used fresh.

The basic unit for semen storage and shipment is an individual plastic straw containing enough semen for a single insemination. Each straw is identified with the sire's name and registration number. If the semen can withstand freezing using liquid nitrogen or dry ice in an alcohol bath, the diluted semen with the glycerol added is slowly frozen. When maintained at -320°F until needed for breeding, semen will stay fertile and can be stored for months or perhaps years. Most of the semen is stored in a liquid nitrogen container (semen tank).

General management practices - Some general management practices will increase AI conception rates if they are followed properly.

1. Avoid breeding diseased or infected females.
2. Have females that have been bred 2+ times without conception checked by a veterinarian.
3. Wait at least 60 days after calving to breed cows back.
4. Sows should be bred back 35-50 days after farrowing.
5. All semen collection equipment should be clean and sterile.

Timing of cattle insemination - The rule of thumb that generally provides good conception rates for cattle herds is: Inseminate approximately 12 hours after estrous is completed. Ovulation occurs 12-16 hours after standing heat.

Insemination techniques - To inseminate a cow properly, the inseminating gun must be inserted into the vagina and directed through the cervix before releasing the semen. Learning the proper technique of artificial insemination usually takes three days of concentrated practice on several cows. Following is a brief outline of the AI technique to give a better understanding of the procedure used.

1. Insert the gun with tip pointed upward at a 30° angle into the vagina. This angle keeps the gun from entering the urethra.
2. After the gun tip is inserted into the vagina, place a gloved hand into the anus of the cow to direct the inseminating gun. Next, direct the gun tip through the vagina and into the cervix. Inserting the gun into and through the cervix can be difficult. If the opening of the cervix is difficult to locate, straddle the cervix with the first two fingers of the gloved hand. Pin the cervix to the floor of the pelvis, and locate the opening of the cervix with the thumb.
3. Next, bring the gun tip up until it strikes the thumb. Insert the gun into and through the cervix by using light but steady forward pressure.
4. The cervical channel consists of three cartilage-type rings. Hold the cervix with the gloved hand until the insemination gun is worked through the three rings.
5. After passing through the three rings, the gun will slip forward with little resistance. When this happens, the tip of the gun will be in the uterine body. Since the uterine wall is thin, you should be able to feel the gun tip with the gloved hand. Next, slowly pull back the gun until it is even with the cervical opening. This ensures that the gun tip is inserted only 2" into the cervix. Otherwise, all the semen will be deposited into one uterine horn instead of both.
6. Take about five seconds to deposit the semen slowly.
7. After properly depositing the semen, slowly pull the gun from the reproductive tract. Clean the equipment.

Timing of insemination in horses - The mare's heat period lasts 2-10 days. The egg is ovulated 1-2 days before the end of the heat period.

Artificial insemination techniques in horses - AI has become popular for use in some breeds of horses. AI is not permitted by some horse breed registry associations. If AI is permitted, fresh semen is required by many breed associations. Normally, breed associations will not accept registration for foals conceived from frozen semen. When AI is used, a syringe is attached by a rubber adapter to a disposable insemination tube. Using a sterile sleeve glove, the inseminating tube is inserted directly into the vagina. Then the gloved fingers open the cervix and pass the rod into the uterus to place the semen directly into it.

Sheep - For many reasons, AI in sheep is not widely used in the U.S. outside of research. There are no reliable indicators of the onset of heat in ewes. The ewe has a small and highly folded cervix, making it difficult to deposit semen directly into the uterus. No suitable long-term storage method has been developed for ram semen. No method has been developed for identifying superior sires. The conception rates from a single insemination are not high enough to produce an adequate lamb crop. Most importantly, the additional labor requirements for AI economically outweigh the benefits.

Timing of swine insemination - In swine, the average length of the heat period is 2-3 days, but gilts' heat periods are usually slightly shorter than those of sows. Ovulation occurs about 40 hours after the onset of heat. However, even with daily observation, it is difficult to know precisely when first standing heat occurs. As a rule of thumb, breeding should take place about 12 hours after observing heat and at 24-hour intervals for as long as the female will stand. Allow at least 2-3 services to provide higher conception rates and larger litters.

Artificial insemination techniques in swine - To inseminate swine correctly, follow these steps.

1. Confine the female in a small pen.
2. Put about 100cc of extended semen in a 4 oz. squeeze bottle with a cone-shaped tip. A large syringe can be used, but it is more difficult.
3. Place a few drops of lubricant on the tip of the rubber spirette. Insert the tip into the vulva, pointing it toward the backbone at a 45° to

avoid the opening of the urethra. The cervix is usually 8-10" inside the vulva, but it can be deeper in larger females.

4. When the cervix is located, start rotating the rubber spirette counterclockwise until it becomes "locked" into the cervix.
5. When the spirette is in place, connect the semen container and begin squeezing the semen through the spirette. If the semen starts to run out of the vulva, release pressure, wait a few moments, and start again.
6. When finished, remove the catheter and clean the equipment.

Problems of using frozen semen - On the average, conception rates with frozen semen are 10-20 percent lower than those obtained with freshly collected semen. Also, litter sizes show a reduction of one pig per litter with frozen semen. When freshly collected semen is used, the results are very close to those of natural breeding.

Poultry - Natural mating in broad-breasted turkeys generally results in low fertility rates. For this reason, more than 90 percent of U.S. turkey breeders use artificial insemination in combination with natural mating. The insemination is done with a syringe.

Estrous Synchronization

For AI and embryo transfer, it is important to have a large number of females in estrous at the same time--hence the term estrous synchronization.

There are different advantages to the use of estrous synchronization, depending on the species. For example, horse breeders often strive to breed their mares so that they foal shortly after January 1. The reason for this is that the racing industry considers all foals a year old on January 1, regardless of when they were born during the preceding year. In the dairy industry, estrous synchronization is used frequently to facilitate the use of AI in heifers.

For all species, synchronizing estrous and (ultimately) breeding times shortens the period from birth to conception of the next offspring. For use with an AI program, it increases the number of females to breed at one time, cutting down on time and handling.

TABLE 6.2 - Optimum Breeding Times

Livestock	Heat length (ave.)	Best time to breed after start of heat
Cattle	18 hours	12-19 hours
Horses	5 days	Third day
Sheep	30 hours	20 hours
Swine	3 days	End of first day

Products Used for Estrous Synchronization

Progestogens - These compounds mimic the hormone progesterone, which is produced by a structure on the ovary called the corpus luteum (CL). Progesterone from the CL controls the timing of estrous by preventing the release of other hormones needed for estrous to occur.

Administering progestogens in oral, injectable, or implant form mimics the action of the CL. Long-term administration (14-21 days) causes the CL on the ovary of the cow to disappear. When the progestogen is withdrawn, the female will typically come into estrous.

In mares, progesterone is effective in suppressing heat in mares that have long and erratic estrous cycles. It has also been used (with less consistent results) to maintain pregnancy in mares with history of abortions.

Prostaglandins - These hormone-like substances are administered to the female to induce the disappearance of the CL, also called CL regression. Regression of the CL causes blood levels of progesterone to fall. This induces estrous within 2-4 days. In all species, the CL is not responsive to prostaglandins early in an estrous cycle; therefore, not all animals would be expected to respond to a single injection.

In 1979, the Upjohn Company of Kalamazoo, Mich., received FDA approval on the use of Lutalyse®, a prostaglandin product, for synchronization of estrous in beef cows, beef heifers, and nonlactating dairy heifers.

Human Chorionic Gonadotropin (HCG) - This hormone, which has been used with some success in horse breeding, stimulates follicles to ovulate. It is most often given when the mare is bred. HCG will normally lead to ovulation of a mature follicle within 48 hours, aiding in appointment breeding (when a stud is being brought in from another farm at a specific date) and helping mares that fail to ovulate.

Syncro-Mate B® - This is the trade name for an estrous synchronization product approved by FDA in 1982. It contains Norgestomet®, a patented, potent, synthetic progestin, and estradiol valerate, a synthetic estrogen. SMB, which is used as an ear implant, is designed to cause cows or heifers to ovulate in a predictable period of time.

Melengestrol acetate (MGA) - This synthetic progesterone suppresses heat in feedlot heifers. A drawback of MGA is that FDA approval is pending. Research has shown that a combination of MGA and prostaglandins can make estrous synchronization practical for cattle producers. Feeding MGA to heifers for 14 days and then following up 16-18 days later with an injection of prostaglandin has resulted in a majority of the heifers coming into heat within five days.

Embryo Transfer

Embryo transfer (ET) is the placing of an embryo into the oviduct or uterus. ET in cattle was developed as a result of research done by Jim Rowson at Cambridge, England, in the early 1950s. The earliest work was done with sheep, then cattle and hogs. The first commercial embryo transfers in the U.S. were done in the early 1970s.

The steps of ET in cattle are:

1. Synchronize estrous in cows that will be used as *donors* of embryos and those that will be used as *recipients* of embryos.
2. Superovulation uses a drug that increases the number of embryos that can be collected from a single female by increasing the number of ova or eggs that she ovulates.
3. Breed the donor cow either through artificial insemination or natural service.
4. Recover the embryos from the donor cow (through a non-surgical method) 6-10 days after breeding.
5. Isolate and characterize each embryo to make sure it is normal.
6. Transfer healthy embryos to the recipient cows, which act as foster mothers.

Pregnancy can be confirmed in the recipient cows by rectal palpation of the uterus approximately 35 days after the transfer. Recipient cows with successful pregnancies from the embryo transfers will give birth to calves that are full siblings. Recipient cows have no genetic influence on the calves they carry. Producers often use recipient cows that are less desirable, grade animals because they make no genetic contribution to the calves that they carry.

The greatest advantage of ET is that it increases the reproductive potential of superior females in much the same way that AI increases the impact of superior males. Both of these reproductive techniques increase the number of offspring from a single valuable animal and the rate of genetic improvement in a herd.

Sexing Semen

Sexing semen determines if the semen contains the X or Y sex chromosome. If the semen contains the X chromosome, it will produce a female; if the semen contains the Y chromosome, it will produce a male.

Being able to obtain semen that has been sexed has great economic importance. Because the dairy producer has little use for bull calves, the use of sexed semen to produce only females would make milk production more efficient. Swine producers could market more pork if they could only produce females because females grow faster than males. The opposite is true in beef cattle and sheep, where males would be desired unless trying to produce replacement females.

Semen is sexed by the amount of DNA present on the X and Y chromosomes. The DNA content of the Y chromosome can be monitored because it contains less DNA than the X chromosome.

Cloning

Cloning of an animal is the production of an exact genetic copy. Cloning usually results from the splitting of embryos, which produces genetically identical twins.

Summary

There are many management and technological techniques to control or synchronize an animal's reproductive cycle. All of the techniques need to be carefully analyzed before a producer decides whether to use any of them.

Credits

Agriscience 332: Animal Science (Student Reference). Texas A & M University: Instructional Materials Service, 1989.

Livestock Nutrition and Feeding (Student Manual). 2nd ed. Columbus, OH: Ohio Agricultural Education Curriculum Materials Service, 1991.

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Gillespie, James R. *Modern Livestock and Poultry Production.* Albany, NY: Delmar Publishers, Inc., 1989.

Herman, Harry A. *The Artificial Insemination and Embryo Transfer of Dairy and Beef Cattle: A Handbook and Laboratory Manual.* 8th ed. Danville, IL: Interstate Publishers, Inc., 1994.

Lesson 1:
Importance of Animal Health

Billions of dollars are lost every year due to general health problems, costing the average livestock producer 15 percent of annual cash receipts. Animal health is a large factor in the profit or loss of a livestock operation.

Careers Associated With Animal Health

There are many animal health occupations. Veterinarians are involved with many activities, including vaccinations, setting up health programs, deworming, curing sick or unhealthy animals, and detecting livestock diseases. They are also important information sources for livestock producers. Veterinarian services are an important part of any rural community that has a livestock base.

A livestock producer is also part of the animal health field. Most livestock producers do a majority of farm vaccinations and treatments, if they have the right facilities and equipment. Livestock producers are the first step in detecting diseases and administering the proper care before the disease affects the whole herd.

An extension livestock health specialist provides information about animal health problems and preventive measures. The Extension Service is a good resource for producers to use for questions about animal health problems. The service provides information about starting health programs, sanitation, and preventive programs.

An animal health products representative or salesperson offers equipment, medication, and necessary tools for administering on-farm treatments.

A livestock health scientist researches new cures and detects new diseases affecting livestock. Research by scientists reveals new drugs and cures every year. These scientists are usually employed by major universities, the U.S. Department of Agriculture, and in industry.

People in animal health enforcement make sure state or national regulations on transportation of animals, quarantining, and health certificates are obeyed. They also monitor livestock diseases so that they do not enter the country.

The animal health field is growing, especially in the service sector. The demand for specialized services grows every year. To meet this demand, anyone entering the animal health field needs a strong educational and experience background.

The Economic Importance of Animal Health

Literally billions of dollars are lost every year because of animal health problems associated with livestock. It costs the average producer 15 percent of cash receipts from livestock sales to cover losses due to poor animal health. This 15 percent means $11 billion lost every year in the U.S. These losses come from diseases of the respiratory, reproductive, and gastrointestinal tracts. External and internal parasites also cause income loss.

Producer losses - The following animal health facts influence the profit or loss of a livestock operation. Approximately 12 percent of the cows bred never calve due to general health problems. About 6 percent of all calves die between birth and weaning. Approximately 10 percent of all calves have scours, and about 18 percent of dairy calves with scours die. Cow-calf operators spend approximately $26.95 per cow on disease prevention and death losses. Approximately 1.5 million cattle are lost every year in the feedlot due to general health and/or nutrition problems, costing approximately $750 million.

About one in 10 dairy females have breeding difficulties due to general health problems. Approximately 40 percent of dairy cows are afflicted with a form of mastitis, which converts into $225 per year, per cow. Remember, mastitis-infected products cannot be used for human consumption.

About 5 percent of all ewes never lamb due to general health problems. Approximately 20 percent of all lambs die between birth and weaning due to general health problems. Approximately 3 percent of all lambs on a finishing ration die for the same reason.

Nearly 15 percent of all bred sows never farrow due to general health problems. Approximately one-fourth of all pigs die between birth and weaning.

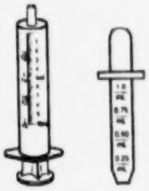
Approximately 50 percent of all bred mares abort or have weak foals due to general health problems. This means that it takes two mares to produce one foal! Approximately 6 percent of all foals die between birth and weaning due to general health problems.

There are also hidden costs associated with animal health that are not figured into the $11 billion lost every year. These hidden costs are reflected by infected carcasses, poor meat quality, added labor costs, retarded growth, salaries for inspectors, depreciation of infected land, and many other costs.

Animal health affects the economics of the average producer, but how does animal health affect the existence of the human race? Some animal diseases can be transferred to humans simply by touching the infected area. There are strict regulations for these diseases because of the effects they could have on humans. Following are some important animal diseases that can be transferred to humans simply through contact and oral ingestion.

Lyme disease - This disease is transmitted usually by a bite from an infected tick or by crushing one on broken skin. The recent increased risk to humans has been caused by more animals bringing the infected ticks closer to human habitations. Human cases of Lyme disease has been reported in the East coast, West coast, Great Lakes, and a few southern states. The closest states to Missouri that have reported human cases of Lyme disease are Arkansas and Tennessee. Human symptoms are a skin lesion around the bite and arthritis in large joints. Sometimes symptoms do not appear until four years after contact. Lyme disease is a curable disease, but there could be some permanent damage to a fetus and some neurological damage, which all can be prevented by early detection.

Brucellosis - Brucellosis is transmitted by touching an aborted fetus, a stillborn fetus, or placental tissues with broken skin; breathing aerosols containing the organism (prominent in packing plants); or consuming unpasteurized dairy products. This organism cannot survive in dry, arid conditions; exposure to direct sunlight; or extreme hot conditions; but under favorable conditions, it can survive 3-4 months. Human symptoms are continued and intermittent fever, headaches, profuse sweating and chills, depression, body aches, and weight loss. Without proper treatment, these symptoms will persist for several months. This disease cannot be transmitted to other members of the family by human contact.



Rabies - Transmitted through the bite of a rabid animal, rabies is a natural disease occurring in animals to regulate over-population. In humans, 90 percent of rabies cases are from wild animals; the other 10 percent are caused by domesticated pets. Pet vaccination is vital in controlling this disease. In humans, rabies is a curable disease if caught in time, but even the cure is very painful.

Salmonellosisis - Transmitted by eating contaminated foods that are not properly stored or cooked. Salmonellosis can be found in pork, beef, poultry, eggs, milk, and even vegetables grown with infected fecal fertilizers. Human symptoms appear as intestinal infections, fever, abdominal cramps, vomiting, nausea, and diarrhea. Salmonellosis is treatable by simply correcting dehydration and electrolyte imbalances.

Trichinosis - This disease is transmitted by eating infested meat. Main sources of trichinosis are under-cooked pork and wild animals, primarily carnivores such as bears. With proper cooking, this disease can be prevented. Symptoms of trichinosis in humans are inflamed muscles or allergic reactions.

Cryptosporidiosis - Cryptosporidiosis is transmitted by eating contaminated food or water, as well as by working around infected fecal material. Generally, people do not even know they are infected by cryptosporidiosis, since the human body develops immunity and gets rid the disease naturally. Diarrhea is the typical symptom. This disease is more prominent in a population infected with Acquired Immune Deficiency Syndrome (AIDS), since their immune systems no longer fight off disease.

Approval of Animal Health Drugs

A new drug usually starts with the discovery of a new compound or the need for a new drug. At the very beginning, a manufacturer must decide if it has the research capabilities for developing a new compound and the usefulness of the new compound. Once the manufacturer decides it is worth the time and effort, the compound begins a long journey for approval.

The research and development process ensures that the compound is effective, safe, and convenient to use. In 1988, animal health institutions spent $340 million dollars on research and development of new drugs. Every new compound must go through the following steps for approval and compliance.

The first step in drug approval is the discovery of a new compound that is suitable for the animal health field. This discovery could be accidental or could occur through research and development.

A compound must go through some preliminary trials. Three questions must be answered before an intense development procedure takes place: 1) Does the new drug have any undesirable traits? 2) What are the estimated costs for research and the anticipated demand for this new drug? What is the potential activity of the new compound? 3) Can it be confirmed that the new drug will do what it is supposed to do?

Pre-clinical trials are the next step in drug approval. Pre-clinical trials target animals that the drug can be used for. These trials are usually done in a laboratory on laboratory animals. Exaggerated dosages are given to determine effects on animals. If the manufacturer is still convinced of the effectiveness of the compound, the manufacturer notifies the appropriate agencies.

The INAD (Investigational New Animal Drug) and the EUP (Experimental Use Permit) are notification applications for the FDA and EPA. These applications show the results of safety, effectiveness, and toxicity studies of the compound. The applications also include plans for continued testing of the compound, as well as small amounts of the compound. After receiving an INAD or EUP file number, the manufacturer makes the final decision to go on with clinical testing, which is the next step in approval.

Clinical trials consist of full-scale field trials. At this point, the manufacturer has made a sizable investment in the compound and has to determine if it will be economical to continue research. Field trials are done on animals targeted for usage. Studies consist of toxicity levels, dosage, residue studies, effectiveness, and blind studies. Studies where the animals are given the compound and the researchers are unaware of which animals received the compound are called blind studies. The data is evaluated to show the effectiveness of the compound.

When clinical studies are completed, a manufacturer can apply for the right to produce the new drug. The manufacturer files for an NADA (New Animal Drug Application) or a pesticide permit, if the compound is a pesticide. A typical NADA application would fill the average volume of an encyclopedia. This application reveals the results of environmental effects, safety to users, animals, and consumers.

Even after the drug or pesticide is approved and marketed, the manufacturer must monitor and report to federal agencies on their findings. Reports are due every six months for the first year, and once a year for the remaining years the drug or pesticide is produced. Further monitoring is done by veterinarians across the country. They report any adverse conditions that occur when using the drug or pesticide.

Population and Individual Medications

It is easy to distinguish between individual and population medications. Individual medications are given to one individual animal. The label verifies the dosage per individual, which is justified by body weight, age, or type of production. Individual medications can be over-the-counter drugs, extra label drugs, or prescription drugs administered by veterinarians. (Extra label drugs carry a veterinarian-written additional label. This label includes information on drug dosage change, duration change, instructions for a different disease, and administration location.)

Population medications are mixed with feed, a complete feed, or fed by themselves. These medications are usually classified as feed additives and administered to a group of animals.

To deworm a pen of finished cattle, mix the dewormer into the feed and medicate the whole group. Population medications are usually mixed into the feed by a certain percentage, such as 2 percent of a ton or not more than 12 lbs. per ton.

As mentioned previously, individual medications are approved after going through a long, expensive process. Population medications or feed additives go through a totally different process for approval, with some aspects similar to individual medications. For both medications, federal agencies regulate their approval.

Interstate and Intrastate Regulations

It is a "buyer beware" market when purchasing and transporting livestock within the state of Missouri. Livestock can be transported anywhere in the state without health certificates. A buyer can request health papers, but the seller does not have to provide them. If a producer buys livestock at an auction, some health tests will be run at the sale barn. The types of tests are decided by the operator of the sale barn. Most purebred and crossbred operations have health papers on all stock in the operation.

Most other states have similar intrastate regulations. Each state has different regulations on interstate transportation of livestock. If a producer in Missouri sold some cattle to a producer in Kansas, the seller is responsible for finding out Kansas health regulations before the cattle can be transported.

Once the seller finds out the requirements for Kansas, a veterinarian can run the required tests on the cattle being shipped. If the lot of cattle pass the required tests, a health certificate is issued by the licensed veterinarian for that lot of cattle. The certificate stays with that group through the entire process of interstate transportation. If the lot does not pass the required tests, the cattle cannot be shipped to that state. A health certificate is not necessary for each state that the cattle pass through--just the state of destination.

There are other regulations that apply to interstate transportation of livestock. First, livestock cannot be transported on a rail car for more than 28 hours without rest, food, and water. This rest period must last for five hours or longer before being loaded back up for transportation. Second, livestock that travel by truck or trailer cannot be transported more than 24 hours without rest, food, and water. Again, they must rest for five hours or more before being loaded.

Summary

It is important to understand the economic importance of animal health and the costs associated with it. As a consumer, it is vital to understand diseases associated with animals and the possible human effects. Consumers and livestock producers should understand the importance of drugs and how they are approved for animal health.

Credits

Compendium of Veterinary Products. Port Huron, MI: North American Compendiums, Inc., 1991.

"Zoonosis Updates for the Journal of the American Veterinary Medical Association." Schaumburg, IL: American Veterinary Medical Association, 1990.

Ensminger, M. E. *Animal Science Digest*. Danville, IL: Interstate Publishers Inc., 1991.

Ensminger, M. E. *The Stockman's Handbook*. 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Lesson 2:
Immune System of Livestock

Diseases in livestock can cause suffering, death, and loss of income to the livestock producer. Fortunately, many of these diseases can be prevented by proper management and by enhancing the animal's natural ability to fight off disease.

Causes of Diseases in Livestock

A disease is any condition that detracts or interferes with an animal's well-being. Diseases are often classified as infectious or noninfectious, depending on whether another living organism enters the animal's body (infects the animal) and by its activity causes disease.

Noninfectious diseases - These diseases are not caused by infectious organisms. However, there are numerous other causes. Nutritional diseases can occur when the animal receives too little or too much of a particular nutrient in the diet. Obviously, if an animal receives nothing to eat, it will starve. Starvation is a nutritional disease; however, most nutritional diseases are more subtle. A deficiency of certain vitamins and minerals can produce a variety of symptoms, such as poor growth, weak bones, weak muscles, poor eyesight, and a decreased resistance to other diseases.

Metabolic diseases can occur when the animal's organs don't function correctly or when the animal undergoes major changes in its life. For example, when a cow gives birth to a calf, she begins producing milk to feed the calf. The cow normally uses calcium from her body to put into the milk. However, some cows use too much calcium from their bloodstream. Since calcium in blood is necessary for normal muscle function, these cows are weak and unable to stand. This metabolic disease is sometimes called milk fever.

Toxic diseases are caused by exposure to poisonous materials. There is a wide variety of poisonous or toxic materials around homes and farms, and the symptoms of disease will differ with the different poisons. Some of the more common livestock poisonings involve farm chemicals (such as insecticides and herbicides) and automotive products (batteries, antifreeze, etc.). Some poisons form when mold grows on grain or hay that is used for feed. Some plants are poisonous.

Certain diseases result from injury or trauma. Lightning strike is one example of an injury that occurs when livestock are on pasture in a thunderstorm. Most injuries are not this dramatic. Some animals become lame after injuring their feet on rough or rocky surfaces. Predator animals (such as wolves and coyotes) may attack and injure livestock. People caring for livestock need to be aware of things that can injure their animals and protect them as much as possible.

Diseases that are present at birth are called congenital diseases. These are often caused by faulty development of the fetus inside the mother's uterus. Some examples are cleft palate (a hole in the roof of the mouth) and ventricular septal defect (an abnormal opening between two heart chambers). If a female calf is twin to a male calf, her reproductive tract may not develop normally. This congenital condition is known as free-martinism and will result in the calf being sterile (unable to reproduce).

Diseases that are inherited from parents are genetic diseases. Symptoms of genetic diseases may or may not be present at birth. One example is porcine stress syndrome. Pigs affected with this disease will become rigid from muscular contractions, and their body temperatures become very high when they are subjected to stress. Additionally, they may have labored breathing, shaking, and blotchy skin. Breeding pigs can be tested for the defective gene that causes this disease. If the parent pigs are free of this defective gene, their offspring will not be affected.

Infectious diseases - Infectious diseases are caused by other living organisms that infect (live in or on the animal) and cause disease. Organisms that can cause disease are sometimes called pathogens. The way that these organisms cause disease varies. Some organisms actually kill the cells or tissues that they infect. Other organisms produce toxins or poisons that have an adverse effect on the animal's body. Sometimes the body's response in trying to rid itself of the infecting organism will cause pain, discomfort, and loss of normal function. Most infectious diseases of livestock are caused by bacteria and viruses. Some diseases are caused by fungi or protozoa.

Bacteria - Bacteria are microscopic, single-celled organisms. Bacteria are very common; in fact, millions of bacteria live inside every normal person and animal. Most bacteria are harmless, and some may even be beneficial. However, a few bacteria are pathogenic (disease-causing) and can be harmful to the animal. Pathogenic bacteria require moisture, warmth, and nutrients to grow and multiply. An animal's body provides all of these requirements.

Bacteria cause disease when they grow in places where they are not supposed to grow or when they produce by-products that are harmful to the animal's body. Some examples of bacterial diseases are *E coli* diarrhea in calves and piglets, blackleg in calves, and erysipelas in pigs.

Viruses - Viruses are extremely small particles that typically consist of nucleic acid centers (genes) surrounded by capsules of protein and/or carbohydrates. Viruses are so small that they can only be seen under most powerful electron microscopes. Viruses cannot grow or reproduce unless they infect the cells of another organism. Pathogenic viruses can destroy cells or change their function in such a way that causes disease. Some examples of viral diseases in livestock are infectious bovine rhinotracheitis (IBR or red nose) in cattle and transmissible gastroenteritis (TGE) diarrhea in pigs.

Fungi and protozoa - Fungi share some characteristics with bacteria; however, they are usually more complex in form. Fungi can consist of more than one cell with different functions. Most familiar fungi (mushrooms, molds) do not infect animals. However, some diseases, such as ringworm and thrush, are caused by fungi, which can infect animals.

Protozoa are single-celled animals. As with bacteria, most protozoa are harmless and some are even beneficial. Some protozoa live inside cattle rumens and help them digest grass and hay. Other kinds of protozoa, such as coccidia, infect animals and cause disease. (See Figure 2.1.)

Types of Immunity

Animals are faced with exposure to potentially pathogenic organisms every day and usually do not get sick from these exposures. Fortunately, animals have mechanisms to ward off these threats to their health: natural and acquired immunity.

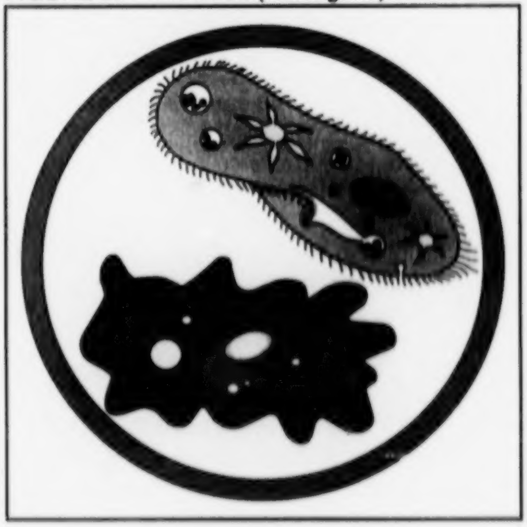
Animals possess natural barriers to infection with disease-causing organisms. For example, the skin is usually an effective barrier and prevents pathogens from entering the body. Mucus from the nose and tears from the eyes usually trap pathogens before they can infect the body.

Also, animals can protect themselves from specific pathogens. Certain body cells examine everything they contact to determine whether or not it belongs there. If these cells come into contact with a pathogen, they recognize that it does not belong, and they then notify the immune system to produce antibodies against that particular pathogen.

Antibodies are protein molecules that bind with the pathogen and help other cells in the body eliminate it. These cells also remember pathogens that they have seen before, so that they will be even more efficient at removing them the next time.

The immune system can be stimulated to produce antibodies against a pathogen by a natural

FIGURE 2.1 - Protozoa (Pathogens)



exposure to that pathogen or by vaccination. This process is called active immunity. In passive immunity, animals may also receive antibodies that another animal has made. This occurs when a baby animal receives antibodies from its mother through the colostrum or first milk. It may also occur when blood serum (which contains antibodies) is taken from one animal and injected into another animal.

Types of Immunizing Agents

Although animals form antibodies against a certain pathogen when they are naturally exposed to that pathogen, it is often better if people help them form antibodies *before* they are exposed to the pathogen. This is done by giving them vaccines. Vaccines are basically a modified form of the pathogen that will not cause disease.

Modified live vaccines are live viruses or bacteria that have been changed so that they will not produce disease. These vaccines are usually very effective at stimulating the animal's immune system.

Killed vaccines consist of viruses or bacteria that have been killed, often by treatment with heat or chemicals. Since the pathogens have been killed, they are not capable of producing disease. Killed bacterial vaccines are sometimes called bacterins.

Toxoids are a form of toxin or poison that has been changed so that it no longer has its toxic effects but it will help the animal produce antibodies against the toxin. The most common example of a toxoid is the tetanus vaccine for horses and sheep. The disease symptoms of tetanus are caused by a toxin, which is produced by the tetanus bacteria, *Clostridium tetani*.

Antisera and antitoxins are antibodies to specific pathogens and toxins that have been formed in the blood serum of another animal. While these antibodies give quick protection against certain diseases, this passive immunity does not last as long as the active immunity stimulated by vaccines and toxoids.

Antibiotics

Antibiotics are compounds produced by microorganisms (often fungi) that either kill or inhibit the growth of other bacteria or fungi. These compounds are most often given either by mouth or by injection to help cure or prevent bacterial infections. Many different antibiotics are available.

Two of the most commonly used antibiotics are penicillin and tetracycline. Some pathogens are resistant to the effects of certain antibiotics, so antibiotics should be chosen based on the susceptibility of the pathogen to that antibiotic. Antibiotics have no effect on viruses; therefore, they are not useful for curing viral infections.

Summary

Diseases can be a significant problem in livestock production. Diseases can be either infectious (caused by a pathogenic organism) or non-infectious. Noninfectious diseases can be nutritional, metabolic, toxic, traumatic, congenital, or genetic in nature. Infectious diseases can be caused by bacteria, viruses, fungi, or protozoa. The animal's immune system fights off infectious pathogenic organisms and can be enhanced by giving vaccines or other immunizing agents. Also, antibiotics can be given to help an animal fight off some bacterial infections.

Credits

Ensminger, M. E. *The Stockman's Handbook*. 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Gillespie, James R. *Modern Livestock and Poultry Production*. Albany, NY: Delmar Publishers, Inc., 1989.

Oram, Raymond F. *Biology Living Systems*. Columbus, OH: Merrill Publishing Company, 1989.

Lesson 3:
Respiratory Diseases Affecting Livestock

Livestock producers or those in related occupations should understand the effects of respiratory diseases on a single operation *and* the entire livestock industry. To prevent diseases from spreading throughout the herd and causing extreme losses, a producer must be able to recognize the symptoms of these diseases. Everyone should understand how outside influences can trigger respiratory infection within a herd. Stress can lead to many infections in livestock. Like humans, animals under stress are more likely to be invaded by viruses or bacteria because their bodies are run down.

Swine

Atrophic rhinitis - Atrophic rhinitis is a highly transmissible disease in swine that causes distortion of the nasal passages. It is caused by bacteria *(Bordetella* and *Pasteurella)*. Infected swine have lower levels of production and are more susceptible to other respiratory diseases. Atrophic rhinitis is not a fatal disease--just an unwanted disease. It is transmitted as an aerosol from an infected hog to a noninfected one. Carriers besides swine include dogs, cats, rabbits, mice, turkeys, horses, and humans.

Sneezing and sniffling are the most common symptoms in swine and are early detections for the disease. Coughing and snorting are other symptoms of Atrophic rhinitis. Inflammation of nose membranes is also a good indication of this disease. As the disease matures, the shape of the nose becomes deformed. The nose turns to one side or the other by as much as 45 degrees.

For prevention, a producer must monitor the herd's contact with outside animals. A producer must also correct environmental deficiencies in sanitation, temperature, humidity, and ventilation. Control dust, drafts, excessive ammonia, and overcrowding.

To treat this preventable disease, a producer must first isolate infected animals to prevent further spreading. Uninfected animals can be protected from *Bordetella* and *Pasteurella* organisms by medicating the feed with sulfamethazine or oxytetracycline.

Mycoplasma pneumonia - Mycoplasma pneumonia transmission occurs easily by contact. Transmission can also occur through infected clothing, dust, and carrying by the wind from shed to shed. Young pigs are most susceptible at 3-9 months. Pigs with Mycoplasma pneumonia that appear to have recovered remain carriers of the disease. Symptoms can reappear if the pigs come under stress. The mortality rates of Mycoplasma pneumonia are relatively low, but secondary infections can increase the risk of death, so treatment is important in controlling the disease.

A dry, hacking, repetitive cough in young pigs is a typical symptom of Mycoplasma pneumonia. Infected pigs remain alert and have a healthy appetite, but they also have reduced growth rates, weights, and feed efficiency. Pigs with acute cases cough and pant and appear to have a fever, little appetite, and a staggering gait.

For prevention, isolate and observe outside animals brought into the herd. This also applies to animals suspected to be infected. After working with infected animals, change and wash clothing worn during the process. Make sure there is appropriate feed and water so the animals do not come under further stress. There are vaccines available to prevent this disease.

There are a wide variety of antibiotics and feed additives to treat animals. It is a good idea to use different medications so that the disease does not become resistant to one specific medication. Keep infected animals isolated in a dry, warm, well-ventilated area with appropriate feed and water.

Pasteurella pneumonia - Pasteurella pneumonia is like most respiratory diseases in that it spreads in the aerosol form. Younger swine are generally affected by the disease. Pigs of 8-24 weeks of age are most susceptible. Mortality rates are high if effective treatments are not administered. If not treated, death can occur as quickly as 5-10 days.

Fever, coughing, depression, mouth breathing, and labored abdominal movements are all typical acute symptoms of Pasteurella pneumonia.

Chronic symptoms are intermittent coughing and signs of ill thrift.

Chilling, dusty conditions, poor nutrition, ration changes, overcrowding, poor ventilation, and poor hygiene can trigger Pasteurella pneumonia. All these factors are signs of poor management.

Infected animals can be treated by injected antibiotics. Other animals that shared the same airspace can be treated with feed or water additives for 5-7 days. Like most respiratory diseases, Pasteurella pneumonia is very treatable and preventable if caught early enough.

Haemophilus pneumonia - Haemophilus pneumonia affects all ages of swine, but generally weaning-age pigs are most susceptible. Like most respiratory diseases, Haemophilus pneumonia transmits in the aerosol form. Mortality rates are as high as 60 percent if not treated quickly.

Severe respiratory distress, severe abdominal respiration, and bloodstained discharge from the nose and mouth are acute symptoms of Haemophilus pneumonia. This particular disease hits fast. Some infected pigs die within a few hours or in couple of days. Pigs that lie and don't want to move show fatal signs of this disease. Chronic cases are usually non-fatal, but they do show signs of ill thrift, persistent cough, fever, and respiratory distress.

There are some good preventive measures for Haemophilus pneumonia. One is to provide well-ventilated, clean, and uncrowded environmental conditions. Treated, infected pigs usually develop immunity to future outbreaks. Also, sows that have been infected and treated will pass immunity to their offspring by colostrum in the milk. It is also a good idea to isolate outside animals for a while to look for any symptoms.

There are several antibiotics available for treatment of secondary infections in affected pigs. Treatments come in the forms of feed or water additives and administered injections. Haemophilus pneumonia is treatable if animals are isolated quickly to prevent spreading of the disease and secondary infections.

Salmonella choleraesuis - This organism enters the body orally, multiplies in the intestinal tract, crosses the intestinal wall, and spreads throughout the rest of the animal. It undergoes its most rapid growth in the lungs and does the most damage there. This disease is most usually seen in pigs from 40 pounds to finish weight but can occur at any age.

The most common sign is sudden death in pigs that had been doing very well. If observation is frequent enough and detailed enough, one may actually see pigs become somewhat listless, experience difficulty breathing, and progress rapidly to severe respiratory difficulty and death. Animals dying from this disease often have purplish discoloration of the ears, belly, and/or feet and lower legs. Clinically, this disease is nearly impossible to differentiate from *Actinobacillus pleuropneumonia*.

Sanitation efforts are extremely cost-effective in preventing this disease because it is transmitted through the feces. Minimizing stress also helps in prevention; many hogs can be carriers but yet will never have problems if they are not stressed enough to lower their resistance. Stressors include overcrowding, drastic temperature fluctuations, feed/water shortages, movement, mixing, etc. While preventive antibiotic therapy and/or use of vaccines can offer some benefit, their long-range cost-benefit ratio will not be as great as improved sanitation and decreased stress.

In an outbreak, water medication and individual injections with appropriate antibiotics are the best approaches. Feed medications can help in long-term control, but sick pigs will simply not eat enough feed to make it a successful treatment method. Antibiotic selection needs to be based on cultures tested in a laboratory and known successes in the local region.

Porcine Reproductive and Respiratory Syndrome (PRRS) - This disease was first diagnosed in the mid-1980s and was originally known as Swine Mystery Disease. It is caused by a type of virus, which produces two known syndromes: a reproductive herd problem and a respiratory syndrome found primarily in pigs younger than 10 weeks old. The virus is usually transmitted by pig-to-pig contact. The virus is shed from the respiratory system, in the feces, and in the semen. There may be some transmission through the air.

PRRS presents itself primarily as a difficulty in breathing that often progresses to a deep cough, rough hair coat, poor growth, and an increase in secondary bacterial infections of the respiratory tract (e.g., *Pasteurella, Bordetella, Haemophilus, Streptococcus, Actinobacillus, Salmonella,* etc.). Incidence of the disease is variable. Death losses can often be as high as 25 percent within a group of pigs. Deaths are from secondary infections, not from the virus itself.

The best prevention is maintaining a negative herd through tight biosecurity and obtaining replacement stock from a known negative herd. In addition, making use of all-in, all-out pig flows will help prevent the disease from ever reaching its most severe level. A commercially approved vaccine is available to help prevent the disease. It is approved for use pigs that are 3-16 weeks old.

There is no treatment for the viral disease itself, so treatment efforts are aimed at secondary invaders that complicate and worsen the disease. Treatment, therefore, depends on which secondary problem exists.

Cattle

Infectious Bovine Rhinotracheitis or "Red Nose" (IBR) - IBR is transmitted by infected droplets that spread by coughing and by nose-to-nose contact. (See Figure 3.1.) The disease can also be spread venereally or by contaminated examination instruments. The virus can be found in infected tissues of aborted fetuses and in nasal or ocular (eye) fluids of infected animals, but it is rarely found in blood. All ages and breeds of cattle are susceptible. IBR can be fatal, but generally it only causes other respiratory and reproductive problems to appear.

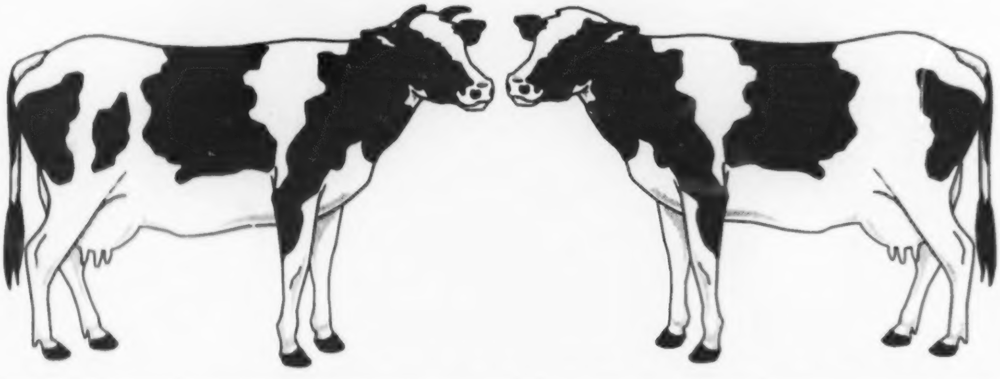
Symptoms associated with IBR are: open-mouth breathing, fever, large amounts of nasal discharge, and a fiery red nose. Other prominent signs of IBR are: depression, lack of appetite, labored breathing, and coughing.

Prevention is difficult since the IBR virus is so widespread; it is hard to find a herd that does not have a carrier. Prevention is usually by vaccines and natural immunity. Less-confined environments reduce chances of an outbreak of IBR. Cattle can develop a natural immunity to this disease, but vaccinations prevent secondary infections and spreading.

Antibiotic treatment of severely affected animals helps suppress secondary infection, but antibiotics have little to no effect on the actual virus. The animals have to rid their bodies of the virus naturally to recover.

Pasteurella infections - Pasteurella is a bacterial infection usually affecting feedlot, grouped, or well-confined animals. This disease can affect all ages of cattle. A Pasteurella infection can spread by droplets in the air, contact, coughing, or feeding

Figure 3.1 - Nose-to-Nose Contact



equipment. This is a very treatable disease, especially in older animals. Fatal cases tend to hit the younger population.

Infected animals show signs of fever, persistent cough, nasal discharge, rapid respiration, and sometimes diarrhea. Other symptoms are depression, lowering of the head, and eye discharge.

Prevention depends largely on good management practices to avoid additional stress on animals. Do not make quick ration changes; avoid overcrowding, outside infections, and stressful movement of cattle. Quickly isolate suspected infected animals.

For treatment, keep isolated animals in a dry, warm, well-ventilated area. Use antibiotics and proper environmental conditions to speed up the recovery process.

Bovine Respiratory Syncytial Virus - BRSV usually targets the younger population of cattle in feedlots. Transmission occurs through the aerosol form or by contact. Generally, weaning-age stock is infected the heaviest with the disease. Cattle that are 6-9 months old are most susceptible in feedlot conditions and have high mortality rates. Older cattle can be affected with the disease, but they have much lower fatality percentages.

Coughing, depression, large quantities of nasal discharge, open-mouth breathing, and frothing are true indications of BRSV. Fever, severe respiratory distress, and extension of the neck are other symptoms. The highest number of reported cases are during July through October. Once environmental conditions cool down, the cases decline in number.

For prevention, producers need to keep a watchful eye on weaning-age stock in feedlot conditions, since this is the most susceptible population. Isolate suspected animals as quickly as possible to reduce the spread of the disease. Do not make sudden changes in diet or water supply because this will place extra stress on the animals. Vaccines are available to prevent BRSV.

Antihistamines and vitamins are used for treating animals infected with BRSV. Revaccinating for IBR has been effective against BRSV. Remember, isolating infected animals and providing proper environmental conditions will aid in treatment.

Bovine Virus Diarrhea (BVD) - BVD infection generally occurs by contact, infected urine, or by the aerosol form. All populations can be affected, but the most susceptible cattle are 6-18 months old. More cases of this disease are reported during the winter and early spring months. A persistently infected bull can spread the disease through his semen to uninfected cows and their fetuses.

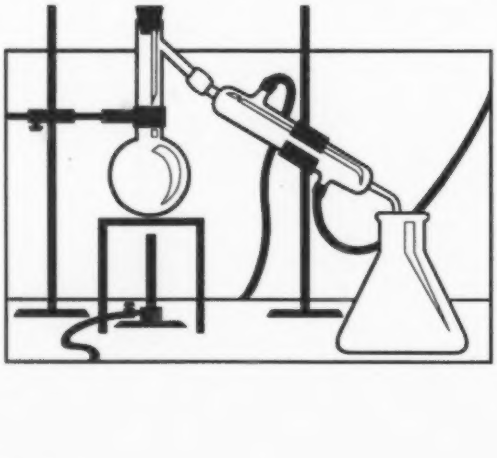
Acute cases generally show signs of a fever, depression, weakness, oral and nasal lesions, dehydration, diarrhea, lameness, nasal discharge, and increased salivation. In acute cases, fatalities usually occur 3-4 days after infection. Since the disease is carried through the bloodstream, pregnant cows can abort their fetuses. Chronic cases can linger for 2-6 months and sometimes past a year. These chronic cases remain carriers for the disease and are a detriment to the herd.

Stress, hormonal changes associated with puberty, and the enhancement of an already existing virus can trigger an infection of BVD.

There are vaccines available to control the spread of the disease. Infected animals usually die, and the ones that survive should be destroyed.

Horses (Equine Family)

Strangles - Due to bacterial *Streptococcus equi*, younger horses are particularly susceptible to strangles, but any horse that has not been infected



before will be susceptible. Infection spreads by inhaling or ingesting droplets breathed or coughed from infected animals. This very contagious bacterial disease affects the upper respiratory tract in horses. This is a very treatable disease, but it can be fatal and spreads quickly.

Animals infected by strangles have a very high fever, coughing, snorting, and thick mucus discharge. The throat, pharynx, and larynx become inflamed, and the animal has difficulty swallowing. Often when food or water is swallowed, these substances are regurgitated back through the nostrils.

Isolating infected animals helps control spreading of the disease. Cold, poorly ventilated, and very confined conditions can lead to an outbreak. Overworked animals and severe weather conditions can also increase the chances for this disease. Since humans can also spread the disease, disinfect all clothing after working with infected animals.

There are several antibiotics for treatment. Early treatment will help prevent abscesses and secondary infections. Isolation of infected animals is very important in treatment and control.

Rhinopneumonitis - This viral disease is transmitted by droplets in the aerosol form. The virus circulates through the bloodstream and localizes in the respiratory tract. Generally, only younger horses contract the disease. It can only be spread in the aerosol form. Horses and donkeys are the only species that are infected naturally. Rhinopneumonitis is a treatable disease, but it has the tendency to abort foals in pregnant mares.

Generally, an outbreak occurs in the autumn and winter months and is usually mistaken for a cold. Horses infected by the disease will have a fever, congestion, and nasal discharge. Sometimes coughing and loss of appetite can be symptoms. This disease is very difficult for a rancher to diagnosis without the help of a licensed veterinarian.

Isolate infected animals from the herd. A rancher could reduce outbreaks by not confining animals to tight, poorly ventilated areas. Vaccinations can be used, but they are not proven 100 percent effective.

There are a number of antibiotics that can be used to control secondary infections. Certain antibiotics are used strictly for nursing mares, and others are used for gestating mares.

Equine influenza - Equine influenza is an acute, highly infectious, viral disease in horses. It is transmitted as an aerosol and has very high mortality and abortion rates. Outbreaks usually occur when moving or grouping horses. This disease is so infectious that horse shows require papers stating that the animal has been vaccinated against Equine influenza.

Symptoms are very similar to other respiratory diseases in horses. These symptoms include: fever, nasal discharge, depression, weakness, dehydration, and loss of appetite. This disease is fatal but can be treated if caught quickly. Death and aborted foals are extreme symptoms of Equine influenza.

For prevention, ranchers and owners must be aware of this disease when grouping or moving horses. They also must be aware of outside contact with other horses. As mentioned before, there are vaccinations to prevent this disease.

Isolating infected horses is vital in treating them and preventing the spread of the disease throughout the herd. Keeping the infected animal in a dry, warm, well-ventilated area will also help in treatment. Antibiotics prevent secondary infections.

Summary

It is important for livestock producers and others in the livestock health field to have a good knowledge base of respiratory diseases, their symptoms, and treatments. The producer is the first step in prevention, treatment, and detection of any respiratory disease because he/she comes into contact with the animals more often than any other person. Everyday observations of livestock are critical for prevention, treatment, and detection of respiratory diseases.

Credits

Black's Veterinary Dictionary. 16th ed. Geoffrey P. West, ed. London: A & C Black, 1988.

Hungerford, T. *Diseases of Livestock.* 9th ed. Sydney, Australia: McGraw-Hill Publishing, 1990.

Stufflebeam, C. *Principles of Animal Agriculture.* Englewood Cliffs, NJ: Prentice-Hall, 1983.

Taylor, R., and R. Bogart. *Scientific Farm Animal Production.* 3rd ed. New York: Macmillan Publishing Co., 1988.

Winkler, J. *Farm Animal Health and Disease Control.* 2nd ed. Philadelphia: Lea & Febiger Publishing, 1982.

Lesson 4:
Diseases of the Gastrointestinal Tract

Good management practices can greatly reduce the spread of disease. An example of a good practice is when the producer cares for healthy newborns first, then does chores with the other animals. Sanitation and disinfection are also very important in killing disease-causing agents and keeping them from spreading. Following recommended vaccination and deworming schedules will eliminate many parasite-related gastrointestinal problems. For newborns, receiving colostrum within the first few hours of birth helps ensure antibody protection against many diseases.

In some sections of this lesson, the "diseases" discussed are actually conditions or problems, rather than infectious diseases.

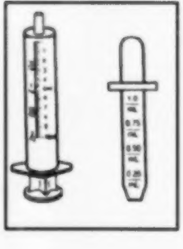
Swine

Baby pig diarrhea - *Escherichia coli* (*E coli*), transmissible gastroenteritis (TGE), rotavirus, coccidiosis, *Clostridium perfringens* type C, and various combinations are the causes of diarrhea in baby pigs. Diarrhea is especially a problem in sows with poor milk flow and in unsanitary, continuous flow farrowing areas.

With any of the baby pig diarrheas, it is better to prevent them with vaccination, cleaning, and disinfection to reduce the number of pathogens in the environment. Vaccines are given to the sow before farrowing so that she will pass antibodies to the pigs through her colostrum.

E coli bacteria adhere to the lining of the small intestine and produce toxins, which cause the intestine to secrete excess fluid. The affected pig has diarrhea and becomes ill from dehydration. Sows can be vaccinated against *E coli* before farrowing. In treatment, antibiotics can help, as can oral or injectable fluids.

FIGURE 4.1 - Oral Syringe and Dropper



The viruses TGE and rotavirus infect and destroy the lining of the small intestine. This prevents the intestines from absorbing nutrients and fluid. The affected pig is contagious and has diarrhea and vomiting, which produces dehydration and starvation. Vaccines for both TGE and rotavirus are available; dehydration can be treated with oral or injectable fluids.

Clostridium perfringens type C is a toxin-producing bacterium that kills the lining of the small intestine. This prevents proper absorption and digestion. The pig can have bloody diarrhea and can die of dehydration and starvation. For prevention, sows can be vaccinated before farrowing. Pigs with diarrhea can be treated with antibiotics and oral or injectable fluids.

Coccidia is a protozoan that infects the lining of the small intestine and eventually causes death with improper absorption and digestion. As with the other pathogens, this produces diarrhea and results in dehydration and starvation. Pigs can only be treated with oral or injectable fluids.

Adult diarrhea and gastrointestinal disease - Causes of these conditions and diseases are swine dysentery, salmonellosis, proliferative enteritis, whipworms, and gastric ulcers. These diseases usually occur after a pig has been weaned but can also occur in adult breeding animals. Good sanitation and all-in/all-out pig flow management will help control these diseases. All-in/all-out pig flow management is farrowing house scheduling in which sows and pigs are moved in and out as groups so proper sanitation and disinfection can keep TGE from spreading to the next group.

Swine dysentery is caused by bacteria. The disease can also be carried by animals that do not show symptoms. Symptoms include bloody diarrhea and inflammation of the large intestine. For control, add appropriate antibiotics to the feed or water.

Salmonellosis is also caused by bacteria—most commonly *Salmonella choleraesuis*. Besides causing diarrhea and inflammation of both small and large intestines, this bacterium can also cause an infection of the bloodstream. Infected pigs often become very sick with high fevers; the skin around their ears, snout, and flank will turn purple.

Antibiotics can be added to the feed or water for control.

Proliferative enteritis is caused by bacteria. It causes an inflammation and thickening of the intestinal lining. This often results in dark, bloody diarrhea. Antibiotics can help with control.

Whipworms are worm parasites. They cause an inflammation of the large intestine and bloody diarrhea. Deworming medicines are the appropriate treatment for whipworms.

Gastric ulcers are caused by several factors, one of which is finely ground feed. Pigs with gastric ulcers do not eat well and can bleed into their stomach. This can cause their manure to look very dark and tarry. There is little practical treatment.

Cattle

There are four major categories that cause gastrointestinal difficulties in cattle: anatomical problems, mechanical problems, toxins, and infections (viral and bacterial).

Anatomical problems - **Displaced abomasum** occurs when the abomasum (true stomach) gets out of position and becomes twisted, thereby affecting the entire digestive system. The exact cause is unknown. Early diagnosis by a veterinarian is important, as a case of simple displaced abomasum can progress to left displaced abomasum (LDA), right displaced abomasum (RDA), or abomasal volvulus, which is life threatening.

Symptoms include decreased appetite, no cud chewing, decreased milk production, abdominal pain, a sprung rib cage, and a temperature. With calves, the main sign is chronic bloating. Diseases such as ketosis, mastitis, and metritis can occur at the same time.

The best precaution against this condition is good feed management. Do not change feed rations too rapidly just before, or immediately after, parturition. Make sure the dietary fiber needs are met in both quantity and fiber size. With simple displaced abomasum, laxatives or antacids can be effective, as can a "rolling" technique. Surgery is usually required for valuable cattle with LDA, RDA, or abomasal volvulus.

Vagus indigestion occurs when the main nerve (vagus nerve) controlling gastrointestinal movement (motility) is damaged or pinched. Clinical signs include lack of appetite and lack of intestinal sounds.

Some cases cure themselves spontaneously and a few respond to veterinary treatment, but many never recover and subsequently die.

The most common **dental problem** is the extreme wear or loss of teeth. This occurs naturally with age and can occur very rapidly, depending on the geographic region and feeding practices. Some diseases, primarily nutrient deficiencies or excesses of calcium, phosphorus, and Vitamins D and A, can affect proper dental development.

Intestinal tortions, intussusception and **hernias** can result in loss of appetite, blockage of the intestine, severe pain, and eventual death. With intussusception, part of the intestine slips into a nearby area, causing obstruction. A veterinarian is required to surgically correct these abnormalities.

A **prolapsed rectum** generally occurs as a result of severe coughing/respiratory disease, diarrhea, or straining from constipation. Correction of the slipped rectum and proper healing requires early recognition, surgical repair, and correction of the true cause.

Mechanical problems - **Hardware disease** is most frequently seen with dairy cows, which are the most haphazard eaters among cattle. Debris that is consumed with forage can include wire and nails. The reticulum/first stomach traps most foreign objects, but a sharp object can perforate the reticulum, liver, or nearby heart. Sharp objects can also affect the lungs or cause leakage of digestive fluids.

An animal with hardware disease will lose appetite, prefer to stand quietly with an arched back, have impaired milk and other body functions, urinate frequently, breath with difficulty, and have a slight temperature. A grunting sound might accompany the pain, especially if pressure is applied to the reticulum area (sternum). With chronic cases, the disease becomes difficult to diagnose because of confusing signs as the hardware moves through the body. An X-ray or exploratory surgery is needed for definite diagnosis.

Hardware disease can be prevented by passing a magnet into the reticulum, where it attracts and holds harmful metal objects. Without the magnet, the animal might heal on its own, or it might have complications and even die. Inexpensive treatment involves reducing feed intake and allowing the animal to remain still. Broad-spectrum antibiotics fight infection. For valuable cattle, surgery to remove the object and drain abscesses is an option.

Bloat occurs when the esophagus becomes blocked where it opens into the rumen; this blockage prevents the animal from burping normal rumen gases. The cause can be something lodged in the esophagus, such as a hedge apple; a cancerous growth; overeating of grain or legumes, such as clover and alfalfa; or injury.

Affected animals are off their feed and have a ballooned left abdominal wall. Severe cases cause both sides of the abdomen to balloon and can result in death due to pressure on the diaphragm and prevention of normal breathing.

Treatment is accomplished by passing a tube down the esophagus to release the gas and by placing supporting medication into the rumen. Severe cases might require surgical release of the gas through the left abdominal wall. This should not be attempted without proper training.

Ulcers can occur at any point along the gastrointestinal tract of cattle. They can be caused by ingested toxins, viruses, or improper diets. True stomach ulcers, like those in people or pigs, occur only in the abomasum. Affected animals are off their feed and can pass dark feces if bleeding is occurring. Treatment usually consists of supportive care and medication until the ulcers heal themselves.

Toxins - Toxins affecting cattle can be from manufactured sources, such as lead, insecticides, herbicides, fertilizer, etc., or naturally occurring plants, such as yew bush trimmings, wild cherry leaves, etc. They are most often taken in orally, but some can be absorbed through the skin.

The effect of toxins on the digestive tract of cattle varies, depending on the type of toxin and the amount. Clinical signs vary from mild lack of appetite to severe constipation or diarrhea. In addition, other organ systems can be affected, making treatment and recovery very difficult.

Successful treatment requires the help of an experienced veterinarian. The proper use of antidotes, laxatives, and absorbents requires professional diagnosis and training. The best treatment, of course, is to prevent exposure to toxins.

Infectious problems (viral and bacterial) - **Scours/diarrhea** is a problem for all ages of cattle, but it is particular deadly for calves younger than 10 days old. Three categories are generally responsible for scours: (1) bacteria—*E coli, Salmonella*, and *Clostridium perfringens* types A, B, C, and E; (2) viruses—rotavirus, coronavirus, IBR, and BVD; and (3) contributing environmental factors, such as overcrowding, lack of colostrum, vitamin deficiency, and parasites. *E coli*-triggered diseases are the largest cause of calf death. Determining the specific cause of diarrhea often requires a veterinarian and diagnostic laboratory.

Symptoms include watery feces, weight loss, dry skin, weakness, and depression. Animals that lose 15 percent of body weight from dehydration generally go into a coma and die.

Dehydration is the main damage caused by scours. It can be treated through oral fluids and electrolyte therapy, much like drinks professional athletes consume after hard exercise. Antibiotics are effective for some causes; consult a veterinarian. For sick calves, milk replacer and electrolytes are used to rehydrate and nourish the calf while it fights the infection (with the help of antibiotics).

Proper management is extremely important, both in treating sick animals and eliminating factors that enhance bacteria and virus growth. Infected animals should be isolated and handled last. Keep newborns from having nose-to-nose contact. Keep birthing pastures or pens clean, treat navels to eliminate infection, and prevent overcrowding.

Many cases of scours can be prevented. Vaccinate pregnant cows against colibacillosis 6-2 weeks before parturition and provide adequate vitamins and minerals. If calves do not receive sufficient colostrum soon after birth, they will not have enough antibodies to fight off infection. Cattle can be vaccinated against *Salmonella, Clostridium*, rotavirus, coronavirus, IBR, and BVD.

Proper internal parasite control is also a must. Parasites (worms and coccidia) cause intestinal irritations that make the occurrence of other infectious diseases much more common. (See Lesson 6 of this unit for more on parasites.)

Horses

Colic - It is the most frequently seen gastrointestinal problem in horses. Colic is not a single disease, but a symptom of pain in the abdomen, usually in the intestines, and is caused by a variety of diseases. Even with the best treatment, some cases of colic can result in death.

Feral or wild horses eat high-fiber/low-energy diets continually as they roam, unlike living conditions in captivity. A horse's relatively small stomach; inability to vomit; and large, free-moving intestines are not well suited to human management, where improper feeding and watering results in colic.

Common causes of colic are sudden changes in feeding or watering, too little forage, overfeeding/overwatering recently worked horses, working horses immediately after a full feeding, moldy grain or hay, and parasite buildup. These factors result in abnormal bowel movements, spasms, or a physical obstruction of the intestine's interior. Spasmodic colic, which accounts for approximately 40 percent of all cases, is a particularly common problem for nervous horses but luckily is the most easily treated.

Symptoms of mild abdominal pain generally include depression, pawing, lack of appetite, decreased bowel movement, yawning, looking toward flanks, excessive lying down, repeatedly getting up and down, frequent attempts to urinate, tail twitching, and kicking at the belly. Moderate pain is indicated if the horse rolls or thrashes dangerously, has patchy sweating, or has rapid breathing. A horse in severe pain will roll and thrash uncontrollably, have profuse sweating, and ignore attempts at restraint. As a species, horses have a very low pain threshold, but no two horses have the same pain threshold. Therefore, similar causes of abdominal disease can cause widely different levels of pain in two different horses.

The horse *must* be kept on its feet while waiting for the veterinarian so that it does not twist an intestine or injure itself by rolling or thrashing on the ground. Walking the horse slowly might help control the pain. In dealing with colic, the biggest problem is determining whether it is **medical** or **surgical** (less than 4 percent of cases). Medical colics can be treated successfully by administering medication and general nursing care. Surgical colics will cause death without surgery. The veterinarian uses many factors, including circulation and intestinal position by rectal examination in an attempt to make this diagnosis.

Treatment for most cases includes pain relievers, laxatives, withholding feed, and/or a follow-up examination. Second opinions, surgery, intensive care, or putting the animal to sleep (euthanasia) might be needed in severe colic cases. If surgery is necessary, 40 percent of the small intestine and at least 50 percent of the large intestine can be safely removed without special dietary considerations.

Diarrhea - Although it is not as common in horses, diarrhea can result from strongyle infestation, too much milk, bacterial and viral diseases, sudden changes in feed, or at the first normal heat after foaling. Animals with diarrhea can be quite contagious and quickly contaminate the area.

Treatment can involve antibiotics and medicines containing kaolin or pectin. Consult a veterinarian if anything stronger is needed.

Summary

The symptoms and causes of many digestive disturbances are very similar. Correct treatment depends on identifying the specific disease properly. Prevention, through proper sanitation and management, seems to be the key to controlling GI diseases.

Credits

The Merck Veterinary Manual. 6th ed. Rahway, NJ: Merck & Co., Inc., 1986.

Blakely, James. *The Brass Tacks of Animal Health*. St. Louis: Doane Agricultural Service, Inc., 1978.

Coffman, James R. "Health Hints for Your Horse" (GO2851). University of Missouri-Columbia Extension Division, 1973.

Cowart, Ross. "Diseases of Swine." Class handout prepared for VP230: Animal Sanitation and Disease Prevention. University of Missouri-Columbia: College of Veterinary Medicine, n.d.

Johnson, Philip J. "Introduction to Colic." Class handout prepared for VMS 610: Equine Medicine and Surgery. University of Missouri-Columbia: College of Veterinary Medicine, n.d.

Keegan, Kevin G. "Colic Surgery." Class handout prepared for VMS 610: Equine Medicine and Surgery. University of Missouri-Columbia: College of Veterinary Medicine, n.d.

Pasquini, Chris, and Susan Pasquini. *Student Guide to Bovine Clinics*. Pilot Point, TX: Suds Publishing, 1993.

Rebhun, William C. *Diseases of Dairy Cattle*. Baltimore: Williams & Wilkins, 1995.

Lesson 5:
Reproductive Diseases in Livestock

Abortions in animals represent genetic and economic losses and often cause a serious disposal problem, especially if abortion resulted from an infectious disease. All reproductive diseases mentioned in this lesson have abortions as one of the symptoms.

Swine

Pseudo-rabies - Pseudo-rabies is an acute, fatal disease occurring in all ages of swine. The most susceptible population consists of pigs less than two months of age. This disease is usually spread by a virus in the sow's milk or in the boar's semen.

Young pigs usually die right away or are aborted by the sow. Older pigs or weaning-age pigs show signs of fever, incoordination, walking sideways, tremors, mouth frothing, eye discharge, and sometimes convulsions. Vomiting, diarrhea, and death will soon follow. Adult swine show signs of fever, vomiting, muscle spasms in limbs, convulsions, or intense itching. Adults might also have respiratory problems. The most prominent sign in female swine is aborting of young.

The only preventive measure is to test all incoming stock for pseudo-rabies. Any stock that tests positively for pseudo-rabies must be destroyed. When restocking the herd, use only stock that tests negatively.

The only treatment is to destroy infected animals to prevent further spreading of the disease.

Leptospirosis - Leptospirosis affects all populations of swine. It is transmitted by wallowing in muddy areas infected by contaminated urine. Other methods of transmission are infected dead pigs and infected outside animals entering confined quarters. The organism usually confines itself to the area of the bladder. The organism can survive for several months in stagnant waters. Infection usually occurs through the nasal and oral passages by nosing at urine or eating contaminated fetus, food, soil, or water.

Reproductive disorders usually appear as abortions, infertility, stillbirths, fever, reduced milk, and neonatal mortality. Acute cases show signs of dullness, diarrhea, hindquarters weakness, incoordination, staggering gait, and stiffness of neck.

Vaccinations are available to prevent leptospirosis. Vaccinations for sows should be given prior to mating and just before farrowing. This method is very beneficial for confined farrowing operations. Animals entering new herds should be isolated, vaccinated, and vaccinated again 4-6 weeks later. Pigs should be vaccinated at weaning and again 4-6 weeks later. Good management practices, such as cleaning pens and eliminating stagnant waters and rodents, are also good preventive measures for leptospirosis.

Feed additives can eliminate carrier animals. Treat the entire herd for 8-11 days. There are several drugs available that are effective in treating infected animals.

Brucellosis - Brucellosis attacks all breeds, classes, and ages of swine. There is no lasting immunity for brucellosis. Infected, recovered animals can be reinfected with the disease later in their lifetime, usually 6-12 months after their first infection. There are several modes of infection. The germ can be present in the urine of both sows and boars, semen, vagina discharges, food and water troughs, sow's milk, and even in the soil. The germ enters the body through the mouth from any of the above sources. The germ can be transferred from pen to pen by human clothing, boots, farrowing crates, and feed buckets. Transmission can also occur when hogs eat or come in contact with infected, aborted fetuses. The disease can be readily transferred from the boar to sow during mating.

In boars, symptoms show up as swelling of one or both testicles. If not caught early enough, the boar generally becomes impotent. An infected sow's symptoms appear in her offspring not in the sow herself. Since each fetus has its own placenta membrane, some pigs are born normally developed, but others might be born dead and underdeveloped. Abortions can occur but are rare in swine. If abortions do occur, the sow generally eats her young.

Isolating and testing sows that have abortions or stillborns are good preventive measures. These measures help prevent further spreading. Good sanitation practices, such as cleaning and disinfecting farrowing crates and other farrowing equipment, are good preventive measures for confined breeding stock. Isolating and testing outside animals entering the herd will prevent an outbreak of brucellosis.

No drugs are available at this time to treat brucellosis. The most effective method of treatment is to destroy them in the proper manner.

Parvovirus - Parvovirus is probably the most infectious virus that affects swine because of its resistance to heat, cold, acidity, alkalinity, and disinfectants. parvovirus affects all breeds, classes, and ages of swine. Infection occurs venereally, by inhalation, and by ingestion. Pigs infected with parvovirus in their adolescent years will develop a natural immunity for the remaining years of production.

Symptoms of parvovirus appear as reproductive problems in swine. Sows have stillbirths, problems conceiving, reduced litter sizes, and mummification of fetuses. Boars will show infertility problems.

Isolate and test suspected infectious animals and outside animals entering the herd. Good sanitation practices are important for prevention because infected animals generally shed the virus in their fecal matter. There are vaccinations available for parvovirus.

Cattle

Brucellosis - Brucellosis is a very contagious bacterial disease in cattle. It is a major concern in the livestock industry because transmission to humans can occur very easily. Bacteria enters the body through the mouth or venereally. Transmission occurs by licking genital organs, infected fetus, infected placenta, or by licking vaginal discharges. Transmission can also occur during natural servicing of females, but is rare. Females are more susceptible than males, and older animals are more susceptible than younger animals. Time of year, climate, and weather have little influence on the brucellosis bacteria.

Abortions in cattle are a significant sign of brucellosis, but this is not always true for every infected female. Other symptoms are weak calves at birth, retained placenta, and vaginal discharge. These symptoms lead to a period of infertility for both the female and male. An infected male will usually have a reduced sex drive and enlargement of one or both testicles.

Calf vaccination is vital in preventing brucellosis from entering a herd. Good sanitary practices and annual brucellosis testing are good additions to a herd management plan.

Isolating infected animals is important in preventing the disease from spreading. Currently, there is no effective means of ridding the disease except through the destruction of positively tested animals.

Mastitis - Mastitis is more common in dairy than in beef cattle because the dairy cow's udder comes in contact with more outside sources. All breeds of dairy and beef cattle are susceptible to mastitis. Mastitis is a reproductive disease because it appears only after birth. Infection usually occurs by bacteria transfer from the milker's hand, milking equipment, flies, or by lying on infected ground. The bacteria enters the body through the hole at the end of the teat. Cows that have been infected with the disease will not build a natural immunity to mastitis; it can reoccur again and again throughout the cow's production lifetime.

Mastitis changes the nature of milk. Infected milk has thick, white, pus-like clots in it. Clots resemble paper spit-wads. The milk usually becomes paler and thinner in nature. Infected milk has a very unpleasant odor since it is infected with pus. The udder becomes hot to the touch, tense, and painful for the animal. The udder might also develop lumps that can be felt by the producer.

There are several teat dips available for prevention of mastitis. Dipping the teats after milking is a good management practice, as are good cleaning procedures in the milking parlor and of milking equipment.

There are several drugs available for treating mastitis. These drugs should be administered to the infected animal until the animal fully recovers.

Infected milk must be disposed of properly. There is usually a waiting period until the milk can be returned to the herd's milk supply.

Metritis - Metritis means inflammation of the uterus or breeding bag. Metritis is not a specific disease but a symptom of a variety of bacterial diseases. Infection can occur venereally, by contaminated obstetrical equipment (calf pullers and chains), by human contact after working with infected animals, and improper clean-up. Predisposing causes for metritis are manually removing or rough removal of afterbirth, and even removing afterbirth before it is ready to be taken away. The retained placenta acts as a wick to the uterus for infection.

Females infected with metritis have inflammation of the mucus membrane lining of the uterus. This inflammation creates outward signs of vaginal discharge in the forms of excess mucus, pus flakes, or excess pus. Breeding problems usually occur, such as conception difficulties, missed heat cycles, and fertilized eggs that cannot attach themselves to the uterus wall. These problems occur because of the inflammation in the uterus. Bulls are usually unaffected by metritis but can be carriers of the disease.

Good sanitation and feeding practices are good preventive measures. If an outbreak occurs, isolate infected animals and make sure equipment and clothing are cleaned after working with them. An outbreak of metritis is more likely to occur in confined areas like calving barns. (There is a higher concentration of infectious diseases than is found outside.)

Several drugs are available for treatment of infected females. Consult a veterinarian for the most effective treatment of metritis.

Leptospirosis - Leptospirosis affects all classes, breeds, and ages of cattle. As with swine, the disease is transmitted through infected urine. Transmission generally occurs by inhaling infected urine droplets that are present in the air. Animals that recover from leptospirosis generally develop a high resistance to reinfection. Low-lying ground with swampy conditions and stagnant bodies of water are predisposing causes of leptospirosis.

Acute symptoms of leptospirosis are fever, depression, failure to eat, and reduced milk production. Some chronic symptoms are abortions, breeding difficulty, death, and retained placenta.

Isolate infected animals to reduce transmission of the disease. If there is an outbreak of leptospirosis in the herd, be aware of any stagnant bodies of water. There are vaccinations available for the prevention of leptospirosis.

Several drugs are available for treatment of cattle. Consult a veterinarian for an effective treatment.

Horses

Metritis - Metritis affects all classes and breeds of equine breeding stock. The most susceptible horses are breeding mares. Infection can occur venereally, by contaminated obstetrical equipment (such as foal pullers and chains), by human contact after working with infected animals, and improper clean-up. Infection generally occurs by retained placenta membranes. The retained placenta acts as a wick for infection directly to the uterus.

Symptoms of metritis are more difficult to detect than other reproductive diseases because they usually appear as breeding problems. Mares show no signs or symptoms of vaginal discharge. The only signs are failure to conceive or maintain pregnancy. Another sign of metritis is repeated service to a known fertile stallion. Sometimes a mare appears to have conceived by missing a heat cycle, but 2-3 months later a fetus is not found (because the fertilized egg could not attach itself to the uterus wall).

If an outbreak occurs, isolate infected animals and make sure equipment and clothing are cleaned after working with infected animals to prevent spreading of the disease.

The following are effective treatments for metritis: local antibiotic therapy, systemic antibiotics, topical antiseptic therapy, uterine flushes, plasma infusion, and a combination of plasma infusions and antibiotics.

Fescue toxicity - Fescue toxicity affects female breeding stock in horses. Infection occurs when gestating mares eat fungi-infested fescue grass. By eating infected fescue, less of the hormone prolactin is produced. Reduced prolactin decreases or eliminates milk production in the mare. This process generally takes place in the last 60 days of gestation.

Fescue toxicity is hard to detect until it is too late. If the mare's diet consists of fescue forage and the mare is gestating, the lack of udder development is a good sign of fescue toxicity. After foaling, signs of fescue toxicity are stillborns and thick, discolored placenta.

A good preventive measure is to take gestating mares off a fescue diet 60 days before foaling to reduce fescue toxicity chances.

Since fescue toxicity is not an infection, treatment for the disease is not necessary to aid in recovery. Good management practices are the most effective way to prevent fescue toxicity.

Summary

It is important for livestock producers and others in the livestock industry to understand the impact of reproductive diseases on the industry. The producer is the first step in detection, prevention, and treatment of reproductive diseases. It is vital that a producer understands the impact of health on the herd.

Credits

Hungerford, T. *Diseases of Livestock.* 9th ed. Sydney, Australia: McGraw-Hill Publishing, 1990.

Taylor, R., and R. Bogart. *Scientific Farm Animal Production.* 3rd ed. New York: Macmillan Publishing Co., 1988.

Abortions can be caused by thousands of factors, so diagnosis of the cause can be very difficult. The diagnostic success rate for abortion is only about 30 percent. Researchers say abortion losses of 2-3 percent can be tolerated without undue concern in well-managed livestock operations. The following factors are obstacles to accurate abortion diagnosis:

1. Abortions generally occur as the result of an event that occurred several weeks or months earlier. If the cause was present at conception, it is usually undetectable by the time of the abortion.
2. The mare usually retains the fetus in the uterus for several hours or days after death.
3. Fetal membranes, which are commonly affected first, are usually unavailable for examination.
4. Toxic and genetic factors can result in abortions but are very hard to discover.
5. Many factors causing abortions are still unknown and are very difficult to detect.

The following factors are considered causes for abortions in livestock:

1. Venereal infections
2. Nonvenereal ascending infection
3. Septicemia - a systemic disease caused by pathogenic microorganisms and their toxic products in the blood
4. Anemia - lack of or reduction in red blood cells
5. Nutritional problems
6. Trauma
7. Genetic defect
8. Toxicity problem
9. Endocrine abnormality
10. Other

Lesson 6:
External and Internal Parasites

Each of the major livestock parasites will be discussed in terms of their hosts, life cycle, damage to the host, symptoms, and control.

External Parasites of Livestock:
Their Symptoms and Treatments

Ticks - Ticks attack all classes of livestock but are of greatest concern to cattle and horse producers.

After leaving the host, adults lay eggs that hatch into larvae in 10-21 days. The larva becomes a nymph and attaches to a host until it becomes a mature adult, which ranges from a few days to several months, depending upon the species.

The greatest damage to hosts by ticks is the sucking of blood, which can cause anemia, weight loss, and even death. They also leave a wound that allows for bacterial infection or other injury. Infestations usually are found by visual inspection.

Extreme temperatures and pasture rotation help control ticks. The most effective method of control is chemical treatment.

Louse - Lice are species specific, and only one species affects swine--the hog louse.

In the life cycle, the adult female glues eggs to the host's hairs. The hatching range is 1-2 weeks, when nymphs are produced. In two weeks to a month, the nymphs become mature adults.

Blood-sucking lice can cause the hosts to become anemic. Irritation and discomfort cause rubbing and scratching. This decreases feeding and grazing time, resulting in loss of gains, unthriftiness, and even death. The primary symptoms of lice infestations are rough hair coats, rubbing, and scratching.

Chemical control with pesticide sprays, dips, dust, and self-treatment devices are most effective.

Mites - Mites attack all classes of livestock. They spend their entire life on the host. The adult female lays its eggs on the surface of the host's skin. Eggs hatch in approximately four days and larvae emerge. The larvae molt, become nymphs, molt again later, and become adults. The entire life cycle takes 12 days or less.

The host's hair comes out and the skin becomes rough and crusty. Symptoms are falling hair and rough, crusty, red skin.

Mites can be chemically controlled. Animals having this pest are placed under quarantine.

Screwworm - The screwworm affects all livestock. Infestation usually is only through wounds; however, some infestations have been found without wounds.

A screwworm is the larva stage of a blowfly. They feed on living flesh for 5-7 days, drop to the ground, and pupate. The larvae or maggots live on live flesh and can cause weight loss, permanent injury, or even death.

The primary signs of screwworms in a wound are an unpleasant odor, enlargement of the wound, and seepage of blood serum (mostly plasma) from the wound.

Topical sprays are available for the treatment and prevention of screwworm infestation.

Heel fly or cattle grub - Cattle are the primary hosts for the cattle grub; however, they have been found in other species of livestock.

The adult fly lays eggs on the host's leg hairs and lower parts of the body. Eggs hatch into larvae that penetrate the hair follicles and enter the animal's body. During a period of months, the larvae migrate through fleshy tissues of the animal's body until they reach the back.

The primary damage is to the hides by causing decreased values from the holes. During the grub's migration to the back, animals can injure themselves trying to get rid of the grubs. There is

Credit: ***Agriscience 332: Animal Science (Student Reference).*** Courtesy of Instructional Materials Service, Texas A & M University, College Station, Texas. Appreciation is extended to IMS for use of portions of the *Agriscience 332: Animal Science* instructional materials.

also damage to meat that must be trimmed away as waste. Egg laying is the most visible symptom of the heel fly. There are visible swellings of the grubs once they arrive in the animal's back.

The best control method is with systemic insecticides before heel flies reach the animal's back.

Horn fly - Cattle are the main hosts, but horn flies will attack other species.

The adult female lays her eggs in manure, where they hatch in nearly 24 hours. Larvae mature in 5-10 days and then pupate. Young flies emerge from the pupae in 3-7 days and become adults in a few days.

The adult fly bites and sucks blood from the head, neck, back, and belly of cattle. The biting results in the transmission of disease, annoys the animal, and indirectly causes weight loss. Horn flies are easily seen on infested animals. Unless they are controlled, horn flies will cover the backs and necks of cattle during spring and summer.

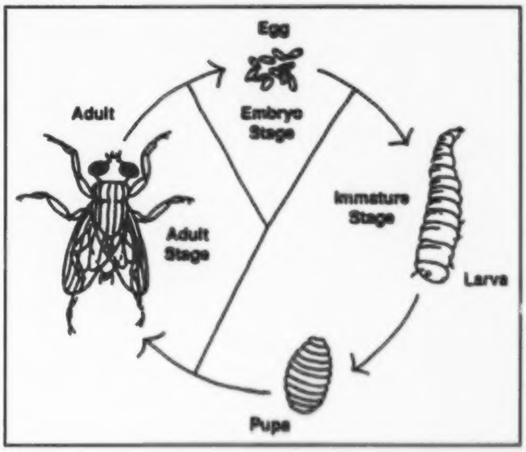
Chemical control is the best method. Feed additives and ear tags are available for controlling horn flies.

Other flies - Flies are parasites of all classes of livestock.

The adult female lays eggs in manure, debris, and other dead and decaying organic matter. Eggs hatch into larvae in approximately 24 hours. The larvae mature and pupate in 5-10 days. Flies emerge from the pupae in 5-7 days, becoming adults in only a few days.

Besides biting, sucking blood, and transmitting diseases, flies annoy animals, indirectly causing lowered feed gains and weight loss. Flies are easily seen, and heavy infestations are common around lots and barns.

Most flies can be controlled with chemical sprays and dusts or feed additives. Because most species build up an immunity to nearly all chemicals, rotation in the use of chemicals is recommended.



Nose bots - The nose bot is a parasite of horses and sheep and is closely related to the heel fly.

The adult fly emerges from the pupae, which lies dormant in the feces and other debris until the first warm days of spring, late summer, and early fall. While grazing, animals rub their noses against the ground, and the fly deposits eggs on the nose and chin of the animals.

Damage results when large bot infestations in the animal's stomach reduce digestion and usually leave an ulcerated area. The presence of the adult fly is very obvious because of the irritation it causes the animal.

Chemical control through deworming is the only method of control.

Internal Parasites of Livestock: Their Symptoms and Treatments

Internal parasites affecting livestock are divided into three major groups: roundworms, tapeworms, and flukes.

Roundworms - From an economic standpoint, roundworms are the most important parasites. There are many types of roundworms, which affect almost every species of livestock. Although there are species that attack every system in the body, the ones of greatest concern are found in the digestive system, mostly the stomach and intestines.

Stomach worms - There are several species of stomach worms, but the twisted stomach worms and the brown stomach worms are most important. Stomach worms are found in all classes of livestock but commonly affect cattle, sheep, and horses.

In the adult stage, stomach worms live as blood-sucking parasites attached to the stomach wall. Eggs pass in the host's feces and hatch into larvae in 15-20 days, depending on temperature and humidity. The larvae crawl up a blade of grass, are eaten by the animal, and travel to the stomach lining until they mature.

While penetrating the stomach lining before maturing, stomach worms cause severe damage by reducing the host's digestion of nutrients and producing poisons. Young, undernourished, or disease animals are hardest hit.

The most common symptom is anemia. In light infestations, the animal will have a dull hair coat, an unthrifty appearance, and will sometimes have scours. In severe infestations, there will be persistent scouring, weight loss, anemia, weakened condition, and possible death.

Sanitation and pasture rotation are good control measures. Chemical dewormers are used to treat infested animals. The type of dewormer used is dependent upon the class of livestock. Drenches and injectable dewormers are most used in cattle and sheep. Feed and water additives are generally used for swine. Liquid dewormers, administered by tubing, are the most effective treatment for horses. Feed additives are also effective.

Strongyles (bloodworms) - There are several species of strongyles, which normally inhabit the small intestine but also are found in the abomasum of ruminants. Strongyles attack all species. They have a greater affect on young animals in each species. After cattle and horses reach an age of 4-5 years, they build up a partial immunity and are less affected.

In the adult stage, bloodworms live as blood-sucking parasites attached to the lining of the intestines. Eggs pass from the host in the feces and hatch into larvae within five to 20 days, depending upon temperature and humidity. The larvae then attach to a blade of grass, are eaten by an animal, pass through the stomach, and attach to the wall of the intestine. The larval stage can live for months in the grass before being eaten. Larvae pass through the arteries and other internal organs, sometimes causing irreparable damage.

Strongyles (bloodworms) are the most detrimental of all internal parasites. Besides sucking blood, which results in anemia, their presence and the scar tissue left by them greatly reduce digestion in the intestines. They are the major cause of colic in horses. Chronic infestations result in unthriftiness, poor feed conversion, weakened condition, and even death.

The most common symptom is anemia. Weight loss, rough hair coats, scouring, loss of appetite, colic, and weakness are seen in moderate and severe infestations.

Sanitation and pasture rotation are effective control measures. The use of chemical dewormers in a regular deworming program is the best method of control. When deworming cattle and sheep, boluses, drenches, and injectable dewormers are the most effective. For swine, water and feed additives are most often used. For horses, tubing at regular intervals plus feed dewormers between tubings give the best results.

Ascarids - Ascarids are primarily parasites of cattle, sheep, hogs, and horses. Younger animals are most often affected.

Eggs are passed in the feces and contaminate pastures, lots, and stable areas, where they are ingested by susceptible hosts. The larvae burrow into the wall of the intestines and migrate through the liver, heart, and finally the lungs, where they are coughed up and swallowed. After reaching the intestines the second time, they develop into the adult stage. Here, they reach a length of 8-15".

Affected animals can develop pneumonia and lung damage due to the larval migration through the lungs. Unthriftiness, weight loss, and colic due to intestinal blockage are common in heavy infestations. Symptoms include weight loss, dull hair coat, general unthriftiness, and colic.

Ascarids are generally controlled by the same means as other stomach and intestinal roundworms. Pasture rotation, sanitation, and deworming programs are the best control measures.

Pinworms - Pinworms are small roundworms usually found in the colon and rectum of horses.

Adult females lay eggs around the anus of the horse. These eggs drop off and contaminate pastures, stables, and watering and feeding areas. After eggs are ingested by the host, they pass to the colon and rectum, where they mature.

Damage by pinworms is minor. However, they do cause severe irritation around the tail area, which causes horses to rub their tails. Tail rubbing is the most noticeable symptom. Also, white scaly deposits are visible around the anus.

The chemical worming programs used to control other species of roundworms will control pinworms. Sanitation measures around barns and lots are effective in reducing infestations.

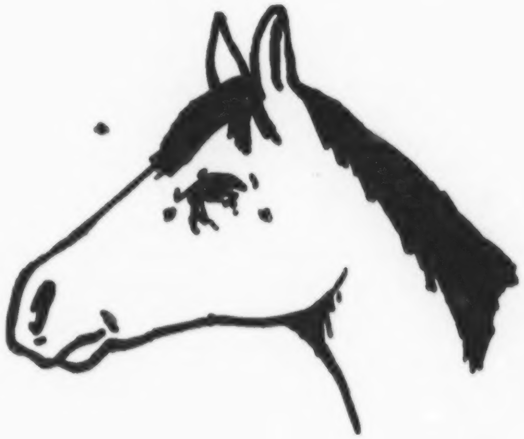
Habronema stomach worm - The horse is the major host of the *Habronema* stomach worm, but the house fly is an intermediate host.

This species affects the host in two stages. The adult stage is found in the horse's stomach, where little damage occurs other than an occasional tumor. Larvae are passed in the feces, which are ingested by house fly maggots. The *Habronema* stomach worm remains in the fly when it emerges from the pupal stage. The larvae of the *Habronema* are deposited on the lips of the horse by the fly, are swallowed, and mature in the horse's stomach.

Real damage of the *Habronema* does not involve its normal life cycle. If the larva is deposited on an open wound, a summer sore develops. These summer sores are difficult to heal and are the result of the migration of *Habronema* larvae throughout the wound. They can permanently disable or disfigure horses. These sores also develop around the medial canthus (corner of the eye nearest the bridge of the nose), especially in stabled horses.

A summer sore is easily detected by a seepy, hard-to-heal crusty sore. In the eye there is excessive tearing and running, which later forms an open sore. The larvae can be seen upon close inspection.

As with other roundworms, disruption of the life cycle is necessary. The best control is a regular deworming program. Sanitation is important, along with a fly control program in and around the stable area.



Lungworms - These roundworms affect the circulatory system and lungs. Lungworms affect all species of livestock.

Eggs are laid in the lungs, then coughed up and swallowed. The eggs hatch in the stomach or intestine, and the larvae are passed in the feces. After a period of development in moist earth or water, the larvae are ingested by the host and pass to the intestine. There, they burrow through the intestinal wall into the lymph nodes and are carried to the lungs, where they mature into the adult stage.

In heavy infestations, there can be mechanical blockage of the lungs, causing a collapse of the infected area. This furnishes an ideal location for the invasion of other organisms. Lungworms can also cause blockage of the windpipe and bronchia.

Coughing is the first indication of this parasite; it is accompanied by faster and more forceful breathing. In severe cases, the animal breathes with its mouth open and its tongue protruding. It is reluctant to move, usually develops a fever, goes off feed and water, and becomes gaunt.

Sanitation and pasture rotation are the best control practices. Chemical control is relatively effective.

Broad tapeworm - In general, tapeworms are far less important than roundworms. The broad tapeworm is a parasite of all classes of livestock, as well as humans.

The adult lives in the small intestine, where it can reach a length of 10' or more. Tapeworm segments containing eggs break off continuously and pass out in the feces. Eggs are eaten by the oribatid mite, which lives in grass and weeds and serves as an intermediate host. The eggs develop in these mites, then are eaten by livestock and hatch in the small intestines. They feed on foodstuff eaten by the animal and grow to maturity.

There is no physical damage to the host. However, the tapeworm is in competition with the host for food. Unthriftiness, loss of weight, diarrhea, and emaciation are the major symptoms. Chemicals can rid the host of tapeworms.

Beef tapeworm - Although the beef tapeworm is a parasite of cattle, humans are the necessary intermediate host.

Beef tapeworm eggs contaminate the feed of cattle and pass down into the intestines. There, the eggs hatch out, bore through the intestinal wall, and lodge in a muscle, causing a cyst. Beef affected by these cysts are called measly beef. The parasite is then passed to humans when infected, undercooked beef is eaten.

There is little economic damage to cattle by the parasite; however, it is a problem for humans. Adult beef tapeworms only live in humans and can reach a length of 25'. There are almost no visible symptoms in cattle except in the carcasses of slaughtered animals.

Since humans are the necessary intermediate host and the beef tapeworm is transferred through the meat, the best control is eating only well-cooked beef.

Pork tapeworm - This tapeworm is the same as the beef tapeworm, except that the larvae live in the muscle tissue of pork.

Liver fluke - The liver fluke is a parasite of cattle, sheep, goats, and humans. It is especially damaging to young animals.

The adult lives in bile ducts, where eggs are laid, pass down into the intestines, and leave in the feces. Eggs must land in water to hatch. The larvae that hatch from these eggs swim about seeking a snail, which is necessary to complete the liver fluke's life cycle. Larvae develop for a period in the snail, then emerge and attach to plants along the water. Livestock eat the water plants and become infested. The young flukes pass to the intestines and burrow through the abdominal cavity and into the liver, where they live principally on blood. Egg production begins about three months after entering the animal.

The fluke causes irritation, thickening of the bile duct, and fibrosis of the liver, making it unfit for human consumption. The usual symptoms are anemia and weight loss. Highly infested animals might die.

Pasture rotation and using water troughs help in control. Chemical treatment will kill adult flukes in the animal. Control of snails will break the cycle, but that is difficult to do.

External Parasites of Poultry: Their Symptoms and Treatments

Poultry producers lose millions of dollars annually to damage caused by external parasites. These parasites transmit pathogens or kill birds, decrease egg production, increase feed costs, reduce weight gains, and lower carcass quality.

Lice - Lice are more abundant in summer than in winter months. Lice are permanent parasites of their hosts. They spend all life stages on the same bird. Sometimes, they will pass from one bird to another, particularly from an older bird to a younger bird.

Although lice eggs are laid singly, they can be abundant enough to form dense clusters on the fluffy area of a bird's contour feathers.

Eggs cemented to the bird's feathers are oval, white, and sometimes beautifully ornamented with fine spines. Eggs hatch in a few days or weeks. Young nymphs immediately begin running about and feeding on the host. After a few weeks, they gradually become adult sized in form and color.

All lice infecting poultry are sucking and chewing types. Lice irritate, cause weight loss, reduce egg production, decrease carcass quality, and can even kill birds. Several species of lice attack poultry. These include: body lice, head lice, wing lice, and fluff lice.

Mites - Mites vary in size and structure. Poultry are susceptible to many types of mites.

Mites usually occur on or under the bird's skin or feathers. A few can exist in body tissues, feather quills, or nasal and respiratory passages such as the air sac. Mites feed by piercing the bird's skin or tissue, sucking blood or body fluids, or by biting bits of skin or feathers.

Mites slow the growth of birds, reduce egg production, lower vitality, damage plumage, and even kill birds. Much of the injury, consisting of constant irritation and loss of blood, is unapparent unless one examines the bird.

Ticks - Several species of ticks affect poultry. These include the fowl tick, Lone Star tick, and Gulf Coast tick. The tick is a bloodsucker and injures poultry by transmitting disease, causing weight loss, lowering egg production, and causing skin blemishes that reduce market value.

Ticks are difficult to eradicate. Houses and surrounding areas require thorough pesticide treatment.

Mosquitoes transmit poultry diseases, including malaria and fowlpox.

General parasite control - Many pesticides exist to control external parasites of poultry. Because the list of approved material changes rapidly, consult a poultry specialist for a recommendation.

Besides applying pesticides, producers can apply good management practices to their operations. Poultry houses and surrounding areas should be free of foreign materials, including manure and stagnant water.

Internal Parasites of Poultry: Their Symptoms and Treatments

Various worms are major internal parasites of poultry. The number of worms that occur in any given bird depends upon the number of infectious eggs that the bird ingests. Worms do not multiply within the host bird. The three major types are roundworms, tapeworms, and flukes.

Large roundworms - Chickens, turkeys, ducks, geese, and pigeons are susceptible to large roundworms.

The large roundworm has a simple and direct life cycle. The female lays thick, heavy-shelled eggs in the bird's intestines. Eggs are expelled in the feces. Poultry eat the eggs, the eggs hatch, and the larvae develop into mature worms to complete the life cycle.

Heavily infested birds exhibit droopiness, emaciation, and diarrhea. Very heavy infestations result in death. Primary damage is reduction in efficiency.

Cecal worm - These exist in the ceca of chickens, turkeys, and other birds. A cecal worm's cycle is similar to that of the large roundworm. This common worm parasite does not affect the bird's health seriously. There are no marked symptoms or pathology occurrences due to the presence of cecal worms.

Capillary worms - Capillary worms occur in the bird's crop and esophagus. The life cycle is direct or bird-to-bird. Worms lay their eggs in the bird's feces. Poultry eat the infected eggs.

The worm produces a mucous membrane inflammation and sometimes causes hemorrhaging. The bird's intestinal lining might erode extensively and result in death. Heavy infestations, especially in houses with deep litter, reduce growth, egg production, and fertility of birds.

Tapeworms - These differ from roundworms because they are flat, ribbon-like, and segmented. They also differ from other worm parasites by having both male and female sexual organs on each segment.

Worms attach to the intestinal lining by suction cups located on the worm's head. Symptoms of tapeworm infestation in poultry include weakness, unthriftiness, and poor growth. Diarrhea develops in some cases.

Tapeworms affect young birds more severely than older birds.

Flukes - Flukes are leaf-like flatworms that affect various parts of a bird's body. Flukes do not cause significant losses in poultry.

Parasite control - Prevention and control of worm infestations involves more than treatment. Proper diet, sanitation, and medication are essential. Poultry should receive feed rations adequate in vitamins A and B complex. Rations lacking these vitamins make poultry more susceptible to worm infestations.

Sanitation practices are essential to prevention and control of worms. Remove poultry litter regularly. Avoid overcrowding birds. Treat infected birds with commercial drugs.

Summary

Proper management and sanitation are the best control measures for both internal and external parasites in all species of livestock and poultry. Proper identification of parasites leads the way to appropriate prevention and treatment. There are many drugs available commercially to help control parasites.

Credits

Agriscience 332: Animal Science (Student Reference). Texas A & M University: Instructional Materials Service, 1989.

The Merck Veterinary Manual. 7th ed. Rahway, NJ: Merck & Co., 1991.

Ensminger, M. E. *The Stockman's Handbook.* 7th ed. Danville, IL: Interstate Publishers, Inc., 1992.

Gillespie, James R. *Modern Livestock and Poultry Production.* Albany, NY: Delmar Publishers, Inc., 1989.

Lesson 7:
Quality Assurance Programs

Livestock associations have developed programs to ensure quality in animal products. Quality animal products start on the farm with the producer; producers should be responsible for their products. This responsibility will instill consumer confidence in animal products and (hopefully) increase demand for these products.

Pork Quality Assurance Program

The pork industry's Quality Assurance Program was developed into three levels. A swine producer interested in the Quality Assurance Program can request information about the program from the National Pork Producers Council (NPPC). The producer must begin on level I and work through the system. The NPPC will send the producer a booklet to read. Afterward, the producer takes an evaluation at the end of the booklet. Once the producer has taken the evaluations for levels I and II and understands the idea of quality assurance, he/she sends the self-addressed card back to the NPPC. The producer will then receive the level III booklet. The producer must follow the guidelines in the level III booklet to qualify for the Quality Assurance Program.

Ten critical control points are outlined in level III for "Quality Assured Pork Production."

Herd health management plan - A producer must establish an efficient, effective herd health management plan. A swine producer should provide a clean, healthy environment, as much as possible. A checklist helps ensure management practices are in line for a healthy swine herd. The herd health management plan also sets up a vaccination program for the herd and compares it to recent trends in the swine industry. The herd health management plan should be completed in the presence of the producer's veterinarian.

Veterinarian/client/patient relationship - A valid relationship exists when three conditions are met: (1) The client or swine producer agrees to the instructions provided by the veterinarian on judgments of animal health and medical treatments; (2) The veterinarian has sufficient knowledge of the client's livestock to make proper judgments on medical treatments; and (3) The veterinarian is readily available for follow-up evaluation on infected livestock to observe any adverse conditions that still exist.

Drug storage - Store all drugs correctly, follow label instructions, and pay close attention to expiration dates. If the label reads, "use the entire bottle," do so or discard the remainder. Store leftover medications in a cool, dry, dark place (preferably a refrigerator). A pick-up dashboard is unacceptable. Clean syringes and discard used needles. Do not store medications in syringes. Keep medications out of reach of children. Keep water or feed additives dry to prevent caking or clumping.

FDA-approved drugs - A producer must always use FDA-approved OTC (over-the-counter), extra label, or Rx (prescription) drugs with professional assistance. Remember, prescription medications can only be given by a licensed veterinarian. Over-the-counter medications can be administered by anyone after carefully reading label directions. Extra label medications require extra instructions from the vet The producer must follow the guidelines on dosage, withholding times, mixing, safety, and efficacy. Producers are discouraged from buying unapproved FDA medications and buying drugs from uninformed suppliers.

Drug administration - A producer must administer all injectable drugs and oral medications properly. Injectable drug administration guidelines follow. Use the smallest recommended needle to reduce stress, minimize tissue and skin damage, and reduce leakage. There are four types of delivery systems for injectable medications. Intramuscular (IM) medication is given in the muscle, subcutaneous (SQ) is given under the skin, intraperitoneal (IP) is given in the abdominal cavity, and intravenous (IV) is given in the vein.

If a producer cannot answer the following questions correctly, he/she must seek assistance from his/her veterinarian to inject medication. Should drugs ever be injected in the muscle of the ham? Are the syringes adjusted correctly to give proper dosages? Do you follow label directions for quantity of medication and site selection? Do you restrain animals to prevent needle breakage and inappropriate dosages?

The producer also needs know how to give water medications. When are water medications used? How do you calibrate medicators? How often do you calibrate medicators? Where do you store medications? How do you flush the lines if medications are used? Are medications mixed fresh daily, and do you monitor consumptions? What is the recording system for water medications?

Following label instructions - Always follow label instructions when using feed additives. A producer must be able to answer the following questions about feed additives (or seek veterinarian assistance). When is the last time the mixer or scale was calibrated, and what time period does the owner's manual recommend? Do you keep written records on calibration dates? When is the last time you did a feed analysis to check mixer accuracy? How often do you check the mixer for wear? How often do you clean your mixer or mill? How do you handle spills of medicated feeds? Do you flush your mixer after mixing medicated feeds? How do you store feed additives? Do you follow label directions and withdrawal times carefully?

Records of treated animals - A producer must maintain proper treatment records and adequate identification of all treated animals. A swine producer is responsible for keeping accurate records on all health-related events associated with livestock. These records must include the identification of animals, what medications were administered, times treated, and withdrawal times.

Drug residue tests - A producer must use residue tests when appropriate. Consider residue testing when sows are culled directly from the farrowing house for selling or marketing. Animals that receive extra label medications should be tested. Consider residue testing swine shown at fairs or livestock shows. Consider residue testing pigs sold to individuals for roasting or for slaughter at private slaughter houses. Newly purchased animals entering the herd should be residue tested since it is rare to receive treatment records for these animals.

Staff medication awareness - A producer must implement employee/family awareness of proper drug use. Swine producers, employees, and family members involved with administering medications should be educated on proper administration techniques and product labeling. Remember, the swine producer is ultimately responsible for those hogs!

Annual checklist - A producer must complete the "Quality Assurance Checklist" annually with the residing veterinarian. Consider this checklist a minimum for swine health programs. This checklist will point out a producer's attitude, knowledge, and commitment to the pork industry.

Beef Quality Assurance Program

The Beef Quality Assurance Program is unlike pork and dairy programs. State associations, rather than the national association, are responsible for setting up quality assurance programs. There are several other differences between quality assurance programs. The Missouri Beef Quality Assurance Program has a code of ethics for producing beef in Missouri. The Missouri association also has set up beef management practices that should be followed by beef producers. Instead of 10 critical control points, the Missouri beef association has five "beef tips" that producers should follow to ensure quality beef products. These tips follow.

Processing cattle - Handle cattle in a way that minimizes bruising when administering injections. Avoid injecting cattle during wet weather to prevent contaminants from entering the injection site. Make sure the injection site is dirt- and manure-free. Avoid using disinfectants when using any modified live virus product. Consider needle size when administering medications. Use smallest needle possible to prevent abscesses. Wet down the work area around the chute to reduce dust or other foreign materials. Secondary infections could result from these materials entering the body at injection sites and open incisions.

Select injection sites carefully. Consider injecting medications in the neck or lower thigh to prevent loss of expensive cuts of meat and market docks. Consider the volume of medication injected at one site. There are limitations on the amount given at a selected injection site. Know the differences between intravenous (IV), intramuscular (IM), and subcutaneous (SQ) injections. Inject these medications appropriately and follow label directions. Always properly place implants to avoid excess trimming of meat. Keep the working area, equipment, and employees clean to avoid any secondary infections when working with cattle.

Current Good Manufacturing Practices - Manufacturers need to follow the following practices to ensure quality beef products. Building, grounds, work and storage areas, and equipment should be routinely maintained, metered, cleaned, and properly stored to ensure purity and intended potency. Manufacturers must keep accurate records of all lab tests done on product testing.

Proper storage for different medications should be designed and maintained. Use proper clean-out procedures on equipment to prevent contamination of products. Use adequate labeling of products to prevent mix-ups and assure that correct labels are used on medicated feed. Production records must be kept on formulation, mixing dates, and shipping dates to ensure quality assurance.

Violations and inspections - If a residue is detected in an animal, the inspector will report the finding to the USDA's Food Safety and Inspection Service. They assign a case number and identification number to the owner of the cattle. The producer will then be asked questions about the incident and why the animal(s) tested positive. Every time the producer ships animals to market, he/she must notify the USDA office of shipments. This monitoring will continue until the USDA office is satisfied that this occurrence will not happen again.

The USDA office reports to the FDA. The FDA then decides whether a follow-up visit is needed. If the violation only occurs once, there will probably not be a visit. If there are several violations, there will be a visit to the facility. The FDA has the legal right to inspect any facility they desire, so producer cooperation is critical.

If you do not cooperate with the FDA during their inspection of the facility, the FDA has several options, all of them serious. The FDA can get a federal court injunction against the facility to halt all further activities. The FDA can file civil or even criminal charges against the producer for not complying with regulations. Also, the FDA can seize all cattle that remain at the facility. Producers must understand label directions about residue withdrawal times or pay the consequences.

Record keeping and inventory control - Beef producers must keep accurate records on all aspects of animal health. To maintain market share and consumer confidence, producers must prove, through effective documentation, that they have a tight control on risk factors associated with animal health. This maintains consumer confidence and strengthen the demand for beef. Inventories on animal health products are also important for beef producers to control. Knowing the amounts of medications and the amounts used are important in maintaining tight control over risk factors.

Feed ingredient quality control - A beef producer must be aware of the implications associated with residues found in feed ingredients. If a producer buys medicated feed from a supplier, which is then fed to the producer's cattle and cause a residue violation, who is responsible? If the producer does not have accurate records verifying that the load of medicated feed was received on a certain date and its contents, the producer is responsible. If the producer has accurate records of all incoming feed ingredients and withdrawal times, the producer can pass the liability to the supplier. Accurate records keep the producer free of any implications related to residue violations from purchased feedstuffs.

Dairy Quality Assurance Program

The National Milk Producers Federation and the American Veterinary Medical Association have produced 10 critical control points for "Quality Assured Dairy Production." The 10 critical control points are as follows.

Preventive health program - A producer must have a preventive herd health management program established. A dairy producer should maintain the herd in a clean, healthy environment, as much as possible. The nutritional program should meet growth, maintenance, and lactation needs of animals. A producer should have the veterinarian implement a health program that encompasses preventive medical procedures and monitoring of reproductive status of breeding stock. Healthy livestock are more profitable and less likely to require drug therapy. Good management practices and health programs keep animals producing efficiently; therefore, they are less dependent on medical therapy.

Veterinarian/client/patient relationship - A valid veterinarian/client/patient relationship exists when the following conditions are met. The client or dairy producer agrees to the instructions provided by the veterinarian on judgments about animal health and medical treatments. The veterinarian needs sufficient knowledge of the client's livestock to make proper judgments. The veterinarian must be readily available for a follow-up evaluation on infected livestock to observe any adverse conditions that still exist.

FDA-approved drugs - Dairy producers should use FDA-approved drugs, whether they are prescription or over-the-counter drugs. The producer must follow label guidelines. Guidelines on dosage, withholding times, mixing, safety, and efficacy are also important.

Grade A requirements - All drug labels must comply with "Grade A" milk control labeling requirements. Over-the-counter drugs used by the dairy producer must have the following requirements specified on the label: (1) the manufacturer's label with indications for use on lactating cows and withholding times and (2) the manufacturer's label with indications for use on non-lactating cows. If used according to label directions, no further instructions are needed.

Prescription drugs used by the dairy producer must have the following requirements specified on the label:

1. The prescribing veterinarian's name and address, in addition to the manufacturer's label indicating milk withholding time on lactating animals
2. The prescribing veterinarian's name and address, in addition to the manufacturer's label indicating use for non-lactating cows

Prescription drugs are given by the veterinarian, and the medication should be used up totally. There shouldn't be any left over; if there is, return it to the vet. It should not be stored at the producer's facility.

Extra label drugs used by the dairy producer must have the following on the label: veterinarian's name and address, active ingredient, directions, and cautionary statements as necessary.

Drug storage - Store all drugs according to "Grade A" milk control labeling requirements. All drugs used in a dairy operation must be stored properly. Storage must not contaminate the milk supply, equipment, or utensils. Drugs used for lactating animals must be stored separately from drugs used for non-lactating animals. Drugs for lactating animals must be labeled for "lactating animals," and the name and address of veterinarian is required if the medication is Rx. Drugs for non-lactating animals must be labeled for "non-lactating animals."

Drug administration - A producer must be sure that all drugs are administered properly and treated animals are properly identified. Before administering or dispensing drugs to any animal, consider the following. What FDA medications are approved for all classes of cattle on the farm? (Use labels.) Do you follow label directions on proper dosages? Do you follow approved routes of administration? Do you follow withholding times? If a dairy producer does not understand any of these questions, he/she should seek assistance from the residing veterinarian.

Treatment records - A producer must keep treatment records and identify treated animals. A dairy producer is responsible for keeping accurate records on all health-related events associated with livestock. These records include identification of animals, what drugs were administered, times treated, and withholding times.

Drug residue testing - Proper drug residue testing capabilities are readily available to producers for on- and off-farm usage. Producers must test milk and urine by appropriate tests for best results.

A dairy producer must consider the following factors to prevent drug residue from entering the milk supply or slaughter residue testing. Consider testing milk from sick animals that have received medication to detect any drug residues. Remember, withholding times on labels are based on healthy animals, so sick animals might have longer withholding times. Consider testing milk on animals that have been given extra label drugs, because extra label drugs do not have official withholding times.

Dry animals returning to the milking herd that have been given any type of medication during dry period should be tested. Consider testing any newly purchased lactating animals, since it is rare to receive treatment records for newly purchased animals. Before sending animals to the sale barn, consider testing the urine of any culled animals and calves that were weaned from treated cows. Urine testing detects any drug residues present in the animals. Calves can be infected by milk from a treated cow. Consider urine or milk testing on animals intended for slaughter to ensure that there are no residue violations during slaughter.

A dairy producer must know and understand precautions and misuses of residue testing. *Never* use residue testing to shorten a withholding time. *Never* test the bulk tank to test milk from individual cows. Treated cows should be tested individually, not with the entire population. *Never* add milk that has tested residue-positive to the bulk tank to dilute it!

Staff medication awareness - Dairy employees must demonstrate a knowledge of proper medication usage and methods to avoid marketing adulterated products. Dairy producers and employees who administer medications should be educated on proper administration techniques and understand product labeling.

Annual checklist - A producer must complete a "Quality Assurance Checklist" annually with the residing veterinarian. Consider this checklist a minimum for dairy health programs. Each dairy operation should be customized to fit the "Quality Assurance Checklist."

Summary

Quality assurance programs help alleviate consumer apprehension about medication usage, placements of injections, drug residues, and environmental conditions. Producers need to make a conscious effort to reevaluate procedures and practices to realign them with these program guidelines. Student awareness of these programs will reenforce the importance of quality production and give them the tools required to defend the industry against opposition or misinformation.

Credits

Milk and Dairy Beef Quality Assurance Program. Stratford, IA: Agri-Education Inc., 1991.

Missouri Beef Quality Assurance Program. Ashland, MO: Missouri Beef Producers, 1990.

Pork Quality Assurance Program. Des Moines, IA: National Pork Producers, 1991.